ON

DISORDERS OF DIGESTION

ON

DISORDERS OF DIGESTION

THEIR

CONSEQUENCES AND TREATMENT

BY

T. LAUDER BRUNTON, M.D., D.Sc., F.R.S.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS; ASSISTANT PHYSICIAN AND LECTURER ON MATERIA MEDICA AT ST. BARTHOLOMEW'S HOSPITAL

London
MACMILLAN AND CO.
AND NEW YORK
1886

TO

ARTHUR GAMGEE, M.D., F.R.S.

This Book is Dedicated

IN ADMIRATION OF HIS SCIENTIFIC ABILITY AND CLINICAL SKILL,

AND

IN GRATEFUL REMEMBRANCE OF THE LESSONS

IN EXPERIMENTAL PHARMACOLOGY AND PHYSIOLOGICAL CHEMISTRY

FIRST RECEIVED AT HIS HANDS, AS WELL AS OF MANY KINDNESSES

DURING A FRIENDSHIP OF TWENTY YEARS,

BY HIS ATTACHED FRIEND

THE AUTHOR.

PREFACE.

When I was requested by the Medical Society to publish the Lettsomian Lectures which I had the honour to deliver before it, I intended to print them alone. But on looking over them I found that in many places I had referred for fuller particulars to papers which I had formerly published, and it occurred to me that some who might wish to consult these papers would be unable to obtain them, and others might like to be spared the trouble of hunting them up. I therefore decided to reprint some of them along with the Lettsomian Lectures. These papers were chiefly read at different times and before different audiences, and contain the same ideas repeated again and again, sometimes in nearly the same words, almost *ad nauseam*. Indeed, if any one should attempt to read this book straight through he will probably throw it aside in utter disgust. But if he will only take the book up now and then at a spare moment, and read a single paper at a time, he may perhaps excuse the repetition, as it makes each paper more complete in itself. Moreover, the reason why certain ideas are repeated again and again is, that they seem to me very important, and I have decided to let the papers remain as they were originally published, without attempting to lessen the repetition, because I hope that the constant recurrence of certain ideas may obtain for them in the mind of the reader the same importance which they have in that of the writer.

The order followed in the arrangement of the papers which follow the Lettsomian Lectures correspond generally to the course taken by food in the body from the mouth to the stomach and intestine, thence into the circulation and tissues, and finally to the excreting organs.

The Lettsomian Lectures were written after all the other papers with one exception, viz. "On poisons formed from food," etc.; they may therefore be considered fairly to represent our present knowledge of the subject of digestion, while the other papers represent our knowledge of a few years back. The ideas which are fully developed in the Lettsomian Lectures are in some cases at least to be found only in their germs in the earlier papers; especially is this the case with the idea of the poisonous action upon the organism of substances formed in the intestine or in the tissues themselves. It may be interesting to some readers to follow the development of these ideas, and therefore a chronological list of the papers has been added to the table of contents.

TABLE OF CONTENTS.

LETTSOMIAN LECTURES.

LECTURE I.

LECTURE II.

LECTURE III.

MISCELLANEOUS ESSAYS.

ON HEADACHE, NEURALGIA, AND OTHER NERVOUS DISEASES CONNECTED WITH THE TEETH.

ON THE PATHOLOGY AND TREATMENT OF SOME FORMS OF HEADACHE.

ON DYSPEPSIA.

ON THE USES AND ADMINISTRATION OF FAT.

ON THE PHYSIOLOGICAL ACTION OF ALCOHOL.

ON THE PHYSIOLOGY OF VOMITING AND THE ACTION OF ANTI-EMETICS AND EMETICS.

ACTION OF MERCURY ON THE LIVER.

ON THE ACTION OF PURGATIVE MEDICINES.

HOW TO MAKE A POULTICE.

ON THE ACTION OF TONICS.

ON THE ACTION OF ALTERATIVES.

INDIGESTION AS A CAUSE OF NERVOUS DEPRESSION.

ATROPIA AS AN ANTIDOTE TO POISONOUS MUSHROOMS.

PHYSIOLOGICAL RESEARCHES ON THE NATURE OF CHOLERA.

ON POISONS FORMED FROM FOOD AND THEIR RELATION TO BILIOUSNESS AND DIARRHŒA.

INTRODUCTORY REMARKS ON THE STRUCTURE AND FUNCTIONS OF THE KIDNEY.

SYMPTOMS, PATHOLOGY, AND TREATMENT OF ALBUMINURIA.

ARSENIC IN ALBUMINURIA.

ON THE PATHOLOGY OF DROPSY.

ON THE ACTION AND USE OF DIURETICS.

CHRONOLOGICAL LIST OF PAPERS.

ILLUSTRATIVE DIAGRAMS, Etc.

LETTSOMIAN LECTURES

ON

DISORDERS OF DIGESTION: THEIR CONSEQUENCES AND TREATMENT.

LECTURE I.

Delivered before the Medical Society of London, January 5th, 1885.

Mr. President and Gentlemen,—I thank you most sincerely for the honour you have done me in appointing me to deliver the Lettsomian Lectures before you this year. The subject I have chosen is one of much practical interest, but it is of such extent that, to deal with it completely, in a course of three lectures, is obviously impossible. I have already discussed the physiological processes of digestion at considerable length elsewhere,[1] and I have therefore less hesitation in passing over those which are well known, with a few general remarks, and dwelling at greater length upon some points which are not so fully described in text-books, although they have important bearings on the practice of medicine.

Man has been defined as a cooking animal. This definition may not be absolutely correct, and there may be some of the lowest races unacquainted with methods of cooking, although other characteristics entitle them to be called men. Yet the definition is, in the main, true, and the fact that man cooks his food, while the lower animals eat theirs raw, is one of the most marked distinctions

[1] Digestion and Secretion, forming Part III. of Sanderson's *Handbook for the Physiological Laboratory*, 1873. London: Churchill. With the assistance of Dr. D'Arcy Power I have revised it for the French translation by Professor Moquin Tandon, 1884. Paris: Felix Alcan.

between him and them. The practice of cooking was familiar to man at a very early stage, indeed, of his history. Long, long before the historic epoch, when man's only implements consisted of broken flints, he cooked his food by roasting, and the charred remains of bones, which he had roasted in order to enjoy the savoury marrow, have been found in caves, along with fragments of the skeletons of the cave-bear, woolly rhinoceros, and other animals long ago extinct.

There is little doubt that roasting was the first method of cooking adopted, for no implements were required, beyond a piece of pointed stick, to hold the food in front of the fire. Boiling is a considerably more complex process, and requires a vessel in which to hold water. This vessel need not necessarily stand fire, because the simplest method of boiling, and the one which was probably first adopted, appears to be that of heating the water by putting red-hot stones into it, until the temperature is sufficiently raised. But after man learned to make pottery, and to bake it in the fire, so that heat could be applied from the outside without the vessel cracking, the simpler plan of boiling the water by putting the earthen pot upon the fire, would be sure to be followed; for man, as a rule, likes to save himself trouble, and usually takes what seems to him to be the easiest plan.

Amongst the various pots of earthenware, early man must have noted the same differences that we do now. We see some pots of thoroughly baked earthenware so hard and strong as to resemble stone; and, indeed, in the case of a Wedgwood mortar, the earthenware is more resistant than almost any stone. Other pots we see of fine china, thin and fragile, which must be handled with the greatest care, lest they break under our fingers. Yet both vessels are equally whole. Turn them round and round, and scan them most minutely, and yet you will find no flaw in either the one or the other. There is no difference between their wholeness, or wholth, or, as we now write it, health; yet the wholeness or health of one vessel is strong, and the wholeness or health of the other is weak. The one may be put to all sorts of purposes, subjected to all sorts of treatment, meet with all sorts of rough usage, and yet it will remain whole or healthy. The other remains whole only so long as it is treated with the greatest care; the slightest rough usage will crack or break it, and then its wholeness or health is gone.

Our early forefathers, when framing a language by which to communicate with one another, had evidently been struck by an

analogy between the implements they used in cookery, hunting, or warfare—those implements by which they maintained the life of their bodies—and those bodies themselves; for they applied the word health to signify soundness in both. At the present day, we sometimes forget the derivation of our word health; but still we are accustomed to qualify it by the adjectives strong and weak, in much the same way as one might speak of the soundness of an earthenware pot.

By strong health, we mean a soundness of body which, like that of a Wedgwood mortar, will enable a person possessing it to go through all sorts of work, be subjected to all sorts of usage, and yet remain sound or healthy. By weak health, we mean a condition of body wherein all the functions go on perfectly so long as external circumstances are favourable, in which the person is fitted to do certain work, and will do it perfectly, provided the calls made upon him be not too great for his strength; but, if he be subjected to any extraordinary exertion, any unusual exposure, or rough usage of any kind, the feeble organism at once breaks down, and is damaged or destroyed.

Not unfrequently we find that a strong earthenware pot, subjected to very rough usage, is cracked; but the crack, instead of completely destroying it, reduces it only from a condition of strength to weakness; so that it remains to a certain extent whole, but is now weak; and unless treated with care, it will readily break, although, if tenderly handled, it may continue useful for a long time. We find a similar condition also in man; and what was originally strong health in a person may be so weakened by exposure, overwork, or the consequences of acute disease, that the health becomes permanently weak, instead of strong.

Health in man, as in other animals, depends upon the proper performance of all the functions. These functions may be shortly said to be three: (1) tissue-change, (2) removal of waste, (3) supply of new material. For the activity of man, like the heat of the fire by which he cooks his food, is maintained by combustion; and just as the fire may be prevented from burning brightly by improper disposition of the fuel, or imperfect supply of air, and as it will certainly go out if fresh fuel be not supplied, and may be choked by its own ashes, so man's activity may be lessened by imperfect tissue-change, and may be put an end to by an insufficient supply of new material and imperfect removal of waste products.

It is with the supply of new material that we have to concern ourselves chiefly in the present lectures, although it is so closely associated with tissue-change and removal of waste, that we shall be obliged to consider these also to a certain extent. The old proverb, "There is many a slip 'twixt the cup and the lip," shows how clearly our forefathers recognised that neither food nor drink was available for the wants of the body until it had actually been taken. Our knowledge carries us a step further than theirs; but even yet we are very apt to forget that both food and drink are useless for the wants of the organism, so long as they are simply in the intestinal canal.

The body may be roughly compared to a cylindrical box, through the centre of which runs a tube, open at both ends, but not communicating with the cavity of the box. Here, it is evident, that anything put into the tube, remains as much outside the box as if it were laid against the outer surface. If the tube be of a different material from the outer wall of the box—if, for example, it be more pervious, liquids or finely-divided powders may pass more readily into the box through the wall of the tube than they would through the outer wall of the box itself; but so long as they do not pass through in this way, they will remain, to all intents and purposes, outside the box; and this is the case with the intestinal tube.

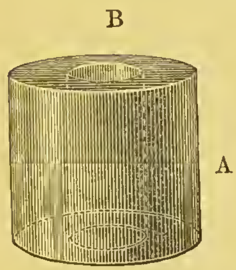

Fig. 1.—Diagrammatic representation of the body. A the box. B the inner tube.

Food and drink, when swallowed, are still outside the body, and in certain circumstances remain so just as much as if they had been laid against the skin. For we sometimes find that food which has been swallowed passes through the intestine, and is evacuated, almost, or entirely, unchanged. It has simply fallen, so to speak, from the mouth to the anus, much as it might have fallen from the neck to the feet, if it had been laid against the skin.

There is, no doubt, one great difference between the skin and the intestine, viz., that the nerves of the intestinal tract are more sensitive than those of the skin, and in passing over the mucous membrane the substance may have exercised a greater action on the body, reflexly through the nerves, than it would have done in passing over the skin, but otherwise the condition in the two cases is much the same.

Another difference is that the epidermis which covers the skin

is much harder and less permeable than the epithelial covering of the mucous membrane lining the alimentary tract; and, therefore, liquids applied to the skin remain unabsorbed, while usually they pass pretty readily into the body from the alimentary canal.

Solids in a very minute state of division, and especially when mixed with fat, may be absorbed by the skin, as we see in the case of inunction with mercurial ointment, where the minutely-divided globules of mercury pass through the skin, are absorbed into the circulation, and are carried by the blood to the various parts of the body. It is most probable, although authorities are not completely agreed upon the subject, that solid particles in a minute state of subdivision are also absorbed by the mucous membrane of the alimentary canal, but the greatest part of the food is absorbed, not in a state of simple minute subdivision, but in a state of solution.

In the alimentary tract, we have provision made both for solution and for absorption, and those two processes are included under the term digestion.

Digestion, like the health generally, may be strong or weak. Some persons are able to take with impunity quantities of fat, pastry, cheese, raw apples, and various kinds of indigestible food, which in other persons would cause discomfort, pain, vomiting, or diarrhœa. Some are able to take meals at all sorts of irregular hours; to do hard work for a whole day without food, and then consume an enormous dinner; to go through all sorts of anxiety without the least diminution of appetite; and to drink all sorts of strong liquors without appearing to be any the worse. Their digestion is both healthy and strong.

Others, again, suffer if their meals are not served exactly at the usual times; a little extra work or a little anxiety will either destroy their appetite or impair their digestive power; a meal somewhat too hearty, or the slightest indulgence in wine or alcohol, is sure to be followed by unpleasant consequences. Yet even those persons may go on for months and years with comfort, digesting their food perfectly, provided only that they take care to fulfil the necessary conditions. Their digestion is healthy, but it is weak.

When digestion is imperfectly performed, we say that the patient suffers from indigestion. Indigestion may occur in those who habitually have either a strong or weak digestion, and by proper methods it may frequently be cured in both; nay, more,

we may sometimes be able to strengthen the naturally weak digestion, though we can hardly expect to alter the natural constitution of the patient, so far as to enable a man who has naturally what is called "a weak stomach" to compete with one who has naturally got the digestion of an ostrich, at a civic feast or at a succession of private dinners.

We have already compared the food by which man's activity is sustained to the fuel which keeps up a fire, but this comparison is not altogether correct. For man is a complex machine, and not only must energy be supplied to the whole body in order to maintain its activity, but the different parts of his body are composed of different materials, and the wear and tear of each must be replaced by its appropriate constituents. A steam-engine not only needs fuel to keep it going, but metal is required to replace the wear and tear of its parts, and oil to lessen the friction of the various parts upon one another. No doubt some of those various necessaries may be replaced by others, and we might, for example, use oil instead of fuel; but this would be a wasteful and expensive proceeding.

Similarly, a mixture of foods is best adapted to supply the energy and repair the waste in the human body. Like the steam-engine, we require oils or fats; proteids, which go, in a great measure at least, to repair the wear and tear of the tissues; and carbo-hydrates, which may be looked upon as, like coal, supplying energy to the organism by their combustion. These various kinds of food are required in different proportions. According to Ranke, about 100 grammes of proteids and a similar quantity of fats are required daily by a man, while two and a half times as much, that is, 250 grammes, of carbo-hydrates are necessary.

Very few substances indeed will supply the requisite ingredients in proper proportion for the wants of the body, and so we usually employ a mixed diet. Black bread is one of the few which contains very nearly the proper proportion of nitrogenous and carbonaceous materials, and, when taken along with a little oil or a few olives, it may maintain a man in health and activity, without the addition of almost anything else except that of a little salt, as is seen amongst the hard-working peasantry in the south of France.

In this country we have generally a more varied diet, and, as a typical meal, we may take a beefsteak with a bit of fat attached, a piece of bread, some salt, and water. The beefsteak supplies fat

and proteids, the bread supplies carbo-hydrates, and the salt and water make up the requisite constituents of food.

But the beefsteak and bread cannot be absorbed in their solid condition, and unless they are absorbed, as I mentioned before, they are of no use to the body. Nor is it sufficient merely to reduce them to a minute state of subdivision, they must be dissolved. The salt which we eat with the beefsteak dissolves in the water without more ado; but the beefsteak itself and the bread will not dissolve without first undergoing some change.

In all processes of solution, the first thing to be done is, if possible, to get the substance which is to be dissolved into a state of minute subdivision.

If we take coarse salt in large crystals it dissolves slowly as compared with table-salt in fine powder, and we accelerate its solution very much by breaking it up, and by stirring it through the water. If we allow it to remain at rest, the layer of water in contact with it soon becomes saturated, and the process of solution goes on slowly, whereas, by stirring, we bring the particles of salt constantly into contact with unsaturated water, and thus solution goes on quickly. In the process of solution, the particles of salt become separated from each other by the water, but the process is a physical one; each particle still continues to be salt, and if the water be removed by evaporation, the residue is salt just as it was at first.

During digestion, a similar process occurs in the case of proteids and carbo-hydrates, but it is carried a step farther. Not only do the particles of proteids and carbo-hydrates become separated from one another by the water, but it penetrates into the chemical molecules of which they are composed, so that a chemical change of hydration occurs, and the large chemical molecules of the proteids and carbo-hydrates split asunder into smaller and simpler ones.

In breaking down the beefsteak or the bread mechanically, we see that we are able to make the particles of which they consist smaller and smaller, until, perhaps, we may be barely able to see each particle with the naked eye. But the process of subdivision does not stop at the limits of our vision, nor even at the limits of our highest microscopic powers. In a perfect solution, the most powerful microscope will fail to discover any particle, and yet we are able by certain methods not only to show the presence of particles, but even to judge of their size.

We estimate the size of particles that we can see, by the size of the mesh in the sieve through which they will pass, and, by a similar method, we are able to judge of the size of the molecules of chemical substances.

Graham showed that some bodies will diffuse through an animal membrane, others will not. Those that diffuse are generally crystalline, those that do not diffuse are generally non-crystalline; but it is probable that the connection between crystallisation and diffusion is to be regarded as accidental rather than necessary, and the real cause why some substances diffuse and others do not, is that the molecules composing them differ much in size.

In experiments on diffusion through artificial membranes, Moritz Traube found that a membrane of tannate of gelatine would allow nitrate of barium with a molecular weight of 130.6 to diffuse through it, and would also allow the passage of all compounds having a smaller molecular weight, but it stopped the passage of ferrocyanide of potassium, having a molecular weight of 211.4.[1]

Membranes may thus be regarded as atomic sieves; and if one substance will not diffuse through a membrane which will allow another to pass, we may consider that the molecules composing the substance which diffuses are smaller than those of the other. This view has an important bearing, as we shall afterwards see, on the causation of certain forms of albuminuria. It is supported, not only by the experiments of Traube on artificial membranes, but by the behaviour of hæmoglobin in regard to diffusion.

Crystalline bodies are, as a rule, diffusable, but they are usually also of much lower molecular weight than organic uncrystalline bodies. There is one crystalline substance—hæmoglobin—which will not diffuse, but it has a very high molecular weight, and probably the chemical molecules of which it consists are very large.

In the process of hydration, the molecules of albumin and of starch do not split down all at once into the smallest molecules to which they may be ultimately reduced by the action of digestion. Between the large molecules, forming the myosin and starch of the beefsteak and bread, and the small ones of peptone and maltose into which they are transformed during digestion, there are a number of intermediate products. In these products, the molecules are probably of varying size, and they diffuse with various degrees of rapidity.

[1] Moritz Traube, *Centralblatt für die med. Wiss.*, 1866, p. 114.

Thus the large molecule of starch breaks down, first into dextrine, and then into sugar. The large molecules of albuminous materials or proteids (including in this term ordinary albumen or white of egg, cooked meat, the casein of milk or cheese, and the vegetable casein of wheat or peas) break down into intermediate substances termed antialbumose, hemialbumose, antipeptone, and hemipeptone, before they are finally converted into peptones. There is less necessity for the molecules of fats to be broken down chemically, because, as we have seen, fats are absorbed even by the skin, and they seem to pass through the mucous membrane of the intestines, and become absorbed, even without decomposition. Their absorption is, however, aided by their being reduced to a fine state of subdivision or emulsion, and this minute subdivision occurs all the more readily by a partial decomposition into fatty acid and glycerine occurring in the digestive canal. The presence of a slight trace of fatty acid greatly aids the formation of an emulsion; and, as we shall presently find, decomposition of fats, with liberation of fatty acid, does occur in the process of digestion.

It may be worth while now to take a short survey of the digestive processes, although time will not allow us to enter at all fully into them.

These processes used formerly to be subdivided into (*a*) those of primary and (*b*) those of secondary digestion. Those of primary digestion are farther subdivided into—

1. Mastication.
2. Insalivation.
3. Deglutition.
4. Gastric Digestion.
5. Intestinal Digestion.
6. Absorption.

Those of secondary digestion may be subdivided into the changes undergone by the products of primary digestion, in—

1. The portal blood.
2. The liver.
3. The lymphatic glands.
4. The general circulation.
5. The tissues.

The first part of the digestive process in man is a very important one, and one which does not receive anything like the amount of attention which it ought; it is the process of mastication. As I have already mentioned, whenever we wish to dissolve anything rapidly, we must comminute it finely. All the food should, therefore, be thoroughly broken up in the mouth. Thorough mastication not only subdivides the food mechanically, but the saliva which is secreted under the two-fold stimulus of the taste of the food and

the movements of mastication tends to dissolve such parts of the food as are soluble in water, and to convert the insoluble parts into a pulp. At the same time, the diastatic ferment of human saliva begins to convert the starch of the food first into dextrin, and then into malt-sugar, or maltose. This conversion goes on very rapidly; and if one chews a piece of stale bread, even for a couple of minutes, a distinctly sweet taste will usually be perceived from the formation of sugar in the mouth.

But the effects of mastication are not limited to the changes produced by it in the food within the buccal cavity; the taste of savoury meat, the rolling of a sweet morsel under the tongue, and the movements of mastication, exert an influence both on the stomach and on the brain.

The effects on the stomach are shown by the observation of Richet, that, in a case of gastric fistula, where the œsophagus was completely occluded, mastication of food induced secretion of gastric juice, although nothing could pass from the mouth into the stomach on account of the obstruction in the gullet.

The effects of mastication on the nerve-centres are perhaps still more important. For it is obvious that the secretion, both of saliva and gastric juice, takes place reflexly through the medium of the nerves; and if the nervous system be dull or depressed, the stimulus of food in the mouth is not likely to excite secretion to the same extent as when the nerve-centres are active.

But provision seems to have been made for this; and the mere act of mastication not only supplies a stimulus to the peripheral ends of sensory nerves in the mouth, it leads to an increased supply of blood to the nerve-centres. This is well shown by some observations of Marey, who found that the current of blood in the carotid artery of a horse became three times as rapid during mastication as it was before. No doubt, part of this increased supply of blood went to the salivary glands and to the muscles of mastication; but it is almost certain that a part of it went also to the nerve-centres. Even if one should deny that any part of the extra current of blood in the carotid, which is consequent upon mastication, goes to the brain, the fact

Fig. 2.—Tracing to show the increased rapidity of circulation in the carotid artery of a horse during mastication.

would still remain that the movements of rolling the morsels about in the mouth, and sucking their sweetness and savour, increases the circulation in the brain, for Salathé[1] has actually observed the fontanelles rise in a child during suction.

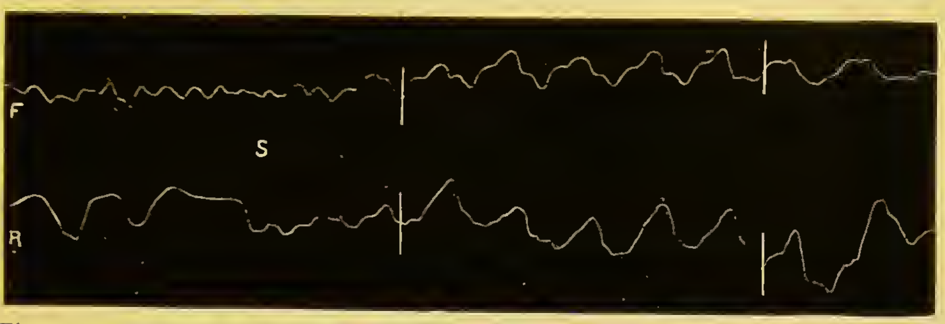

Fig. 3.—Pulsations of the fontanelle (F) in an infant six weeks old while sucking. R shows a simultaneous tracing of the thoracic respiration. The breast was offered to the child at the beginning of the tracing. At the time indicated by the third respiratory wave, which has a flattened top, the child began to take the breast. It will be noticed that the line of the tracing F rises, indicating increased circulation on the brain.

When the food has been thoroughly masticated, it is swallowed, and the act of swallowing sets in action a mechanism which is calculated to increase the blood-supply, not only to the nerve-centres, but to all the glandular structures concerned in the digestive tract. Kronecker has discovered that the act of swallowing seems to remove entirely the inhibitory action of the vagus upon the heart, for the time being, so that the pulse becomes exceedingly rapid. The extent to which this occurs will hardly be credited by any one who has not tried the experiment. In my own case, I find that sipping half a wine-glass full of water will raise my pulse from 76 to considerably over 100. So that, in fact, a glass of cold water, slowly sipped, will stimulate the heart as much, or more, as a glass of brandy swallowed at a draught.

The stimulant effect of sucking is soon learned by children, and we see them console themselves, and raise their spirits, by sucking their thumb when they are depressed by being chidden, or by any childish misfortune; in fact under conditions similar to those under which children of an older growth might keep their spirits up by pouring spirits down. A part of the stimulant effect of sucking is probably due to its action on the heart as well as to a stimulant action upon the cerebral circulation.

When the food arrives in the stomach, it will, if mastication has been properly performed, and the digestive fluids have been

[1] Marey's Travaux for 1876, p. 354.

properly secreted, find a supply of gastric juice already in the stomach, and this will continue to increase in quantity during the progress of the meal. The alkaline saliva swallowed with the food will act as a further stimulus to the secretion of the acid gastric juice, but soon the quantity of acid will be sufficient not only to neutralise the alkali, but to leave a little acid over. The amount of free acidity is, however, very slight, because the hydrochloric acid which the gastric juice contains, combines, for the time being, with pepsin and proteids, forming a compound which does not give an acid reaction.

The starch which has begun to be converted into dextrin in the mouth, undergoes still further conversion by the saliva which has been swallowed. It has not yet been definitely settled whether or not the action of the saliva is so far arrested in the stomach as to prevent the formation of more sugar, but, at all events, it appears to be certain that dextrin is formed, and this is a fact of very considerable importance, as we shall see when we come to consider the order in which food is usually taken at meals.

Albuminoids, or proteids, under the action of the gastric juice, swell up, and are more or less completely dissolved. The large and complicated molecules which compose them appear, as already mentioned, to be broken up into simple ones by a process of hydration. First of all, they appear to form a compound with acid, termed syntonin, or acid albumen. This is soluble in acid, but when the solution is neutralised the albuminoid is again precipitated. The next stage appears to be the formation of a body known as pro-peptone, hemi-albuminose, or parapeptone. This body is not coagulated by heat, and is soluble in water in the presence of weak acids or alkalies. It is precipitated by nitric acid, but when the mixture is heated it dissolves, and a precipitate forms again on cooling. This reaction is important, because it is used to detect hemi-albuminose when this substance appears in the urine, as it sometimes does.

The last stage is the formation of true peptones, which are not coagulated by boiling, nor by nitric acid, nor by acetic acid and potassium-ferrocyanide. They diffuse very easily through animal membranes, and in this respect they differ very greatly from other forms of albumen. By dissolving albuminous substances in artificial gastric juice outside the body, we can produce peptones, and these are sometimes of great service as nutrients in disease. We almost always notice that the product of such artificial digestion has a

disagreeable bitter taste. The cause of this bitterness has not yet been thoroughly investigated. We know, however, that amongst the strongest bitters with which we are acquainted are some of the organic alkaloids; for example, strychnine, the bitterness of which can be perceived in extremely dilute solutions. Now, the organic alkaloids are, to a certain extent, related to albumen, inasmuch as they both belong to the aromatic series of organic compounds, and several alkaloids have been obtained from decomposing albumen. To these alkaloids the name of ptomaïnes has been given. This relationship between alkaloids and albuminous substances would almost lead us to suspect that the bitterness developed during gastric digestion might be due to the formation of an alkaloid. As I have already said, it is not certain that this bitter substance is an alkaloid, but it is certain that an alkaloid has been obtained by Brieger from peptones formed by gastric digestion. By extracting a quantity of gastric peptones with amylic alcohol, he obtained an alkaloid free from peptones which had an action like that of curara. To this alkaloid he has given the name of peptotoxine.

Every effect has got a cause, if we can only find it out; but we not unfrequently ascribe effects to the wrong causes, and perhaps this may be the case with regard to the activity of the pylorus. While the food remains in the stomach, it is mixed up thoroughly with the gastric juice by a sort of churning movement of the gastric walls of the stomach, the pylorus remaining contracted, so as to prevent the gastric contents from escaping in any large quantity into the duodenum.

At the end of three or four hours, however, the pylorus relaxes, and the chyme escapes out of the stomach into the duodenum. This alteration in the behaviour of the pylorus, at the end of a certain time, has been ascribed to the increasing acidity of the chyme; but this seems a little doubtful, inasmuch as we frequently notice cases of abnormal acidity, where the food is retained in the stomach for an excessive time, instead of being passed on too rapidly to the intestines. This is a point upon which we are at present quite unable to speak with any certainty; but the discovery that an alkaloid is formed during the process of digestion in the stomach opens up a new field of inquiry, and may lead us to ask whether the different behaviour of the stomach, at the end of three or four hours, is not partly due to the action of this alkaloid upon it, though no doubt the simplest explanation is, that it is merely a rhythmical function like sleep or waking.

During the process of digestion in the stomach, fats become partially decomposed, and a small quantity of fatty acids are formed, which aid in emulsifying the remainder of the fat.

When the chyme passes through the pyloric orifice into the duodenum, it meets with the bile and the pancreatic juice. These neutralise the acid chyme, and render it alkaline. The further action of pepsin is thus prevented, and the albuminous substances, which have only been converted into syntonin, or acid albumen, are precipitated. The pancreatic secretion is the most energetic and general in its action of all the digestive juices: it unites in itself the action of the saliva and the gastric juices, besides having properties of its own. Like the saliva, it converts starch into dextrin and sugar, and it finishes the work which the saliva had begun.

Like the gastric juice, it dissolves albuminous bodies, forming peptones, though it does not dissolve them in quite the same way. The gastric juice causes them to swell up before they dissolve. The pancreatic juice attacks them from the outside, and makes them crumble away. We do not yet know whether there is any distinct difference between the peptones formed by the action of the pancreatic and gastric juices, but it seems not at all improbable that differences should exist.

In addition to its action on starch and albuminoids, the pancreatic juice emulsifies fats, and tends to split them up into fatty acids and glycerine.

This emulsifying action is aided by the bile, which appears to have a considerable power to facilitate the passage of fat through animal membranes. This can be readily shown by trying to make oil pass through an animal membrane wetted with water, and another similar one wetted with bile. The oil will pass through the latter much more readily than the former. The action of bile in dissolving fats is indeed popularly known, and it is used for removing oil-stains from articles of furniture. In an examination on physiology some years ago at South Kensington, the question was put, "Where is bile formed, and what are its uses?" One candidate's answer was, "Bile is formed in the stomach, and is used for cleaning carpets." The knowledge of physiology displayed by this student was somewhat inaccurate, to say the least of it; but his answer may serve to impress upon our memories the fact that bile has the power not only of removing stains of grease from the surface of vegetable fabrics like carpets, but of enabling oil to pass through animal tissues, such as mucous membranes.

But the bile has another very important function: it tends to prevent putrefaction. Now the minute vegetable organisms which give rise to putrefaction are to be found almost everywhere; and they pass into the intestine with our food and drink. The healthy stomach, with its acid secretions, does not afford them a suitable nidus, but the products of pancreatic digestion seem to form a soil especially favourable to their development. If we digest a piece of meat with pancreas for twenty-four hours at the temperature of the body, we usually find that not only has the meat become dissolved, and peptones formed, but that the peptones themselves have undergone a further decomposition, and that leucin, tyrosin, naphthilamine, and a substance termed indol, nearly allied to indigo, but with an abominable smell, have been formed. Indol is not a product of the decomposition of nitrogenous matter by the pancreatic ferment; it is due to decomposition caused by the presence of putrefactive bacteria.

The same changes which occur in pancreatic digestion outside the body may, and sometimes do, occur inside the body. In health, their occurrence is probably rather the exception than the rule; but, were it not for the antiseptic action of the bile, their occurrence would probably be the rule, and not the exception. It may seem, perhaps, to some persons that the occurrence of putrefaction is of no great consequence; but when we remember that during putrefaction, organic alkaloids which have a poisonous action are formed in the body, it is evident that, if putrefaction takes place to any great extent in the intestine, there may be a risk of actual poisoning by the absorption of organic alkaloids formed in the intestinal canal.

From the duodenum onwards to the rectum, the reaction of the intestinal contents remains alkaline, and so there is nothing to arrest the further action of the pancreatic ferments. The action of the intestinal juice on the food is not as yet perfectly understood, and various conflicting statements have been made regarding it. One reason of this conflict probably is, that the action of the intestinal juice has been tested upon the raw constituents of the food, and not upon foods which have already been altered by exposure to the action of the gastric and pancreatic juices. The intestinal juice is said to have no action on coagulated albumen, and this appears to be the case; but when I was working in his laboratory at Amsterdam, Professor Kühne informed me that intestinal juice would dissolve coagulated fibrine, which had been

previously rendered soluble, but not peptonised, by pancreatic juice.

As the food passes through the large and small intestine, those portions of it which have been rendered soluble by digestion are gradually absorbed by the veins and lymphatics, and carried into the general circulation.

Almost immediately after entering the blood-vessels, changes appear to occur in the peptones. These appear to be taken up, to a great extent, by the red blood-corpuscles, and converted by dehydration into a larger and more complicated albuminous molecule, namely, that of globulin. The blood-corpuscles thus form, as it were, a store of albuminous material, which they convey to all parts of the body, and give off where it is wanted.[1]

But the whole of the peptones do not appear to undergo this change; part of them appear to be arrested in the liver, and to form glycogen, as it has been found that the quantity of glycogen in this organ is increased by the injection of peptones into the bowel.[2]

The sugar also becomes dehydrated, and glycogen is produced from it likewise. This is stored up in the liver for a variable time, and then gradually given out again to supply the wants of the organism. The liver, therefore, acts as a wise steward, laying by provision for the organism in the times of plenty after a full meal, and giving it out again in times of fasting.

But this is not all. The liver acts not only as a wise steward but as a watchful porter. We know that one of the most striking points in the action of such powerful poisons as the venom of vipers and curara is that, though so deadly when injected into a wound, they are almost completely innocuous when swallowed. We know that one reason of this is, that they reach the general circulation much more slowly from the intestine than from the wound, so that the kidneys have time to excrete them, and prevent their accumulating in the blood. It is the liver which is the chief agent in retarding the absorption of poisons into the blood, and thus rendering them comparatively innocuous when they are introduced into the intestinal canal. All the blood from the stomach and intestines must pass through the portal vein before it can reach the general circulation; and, as our forefathers recognised by the name they gave to the porta or gate of the liver, the hepatic

[1] G. Fano. Lo Sperimentale. Settembre e Ottobre, 1882.

[2] Seegen Pflüger's Archiv. xxviii. p. 99.

tissue acts the part of a prudent porter at the gate, and turns back or destroys dangerous intruders. Poisons injected into the duodenum are absorbed into the portal vein; but they are removed from the blood by the secreting tissue of the liver, and poured back again with the bile into the intestinal canal. Again, they undergo reabsorption, and round and round they may go in a circle, from intestine to liver, and from liver to intestine again, without ever being able to pass into the general circulation, or produce any direct effect upon heart, lung, brain, or kidneys (p. 41).

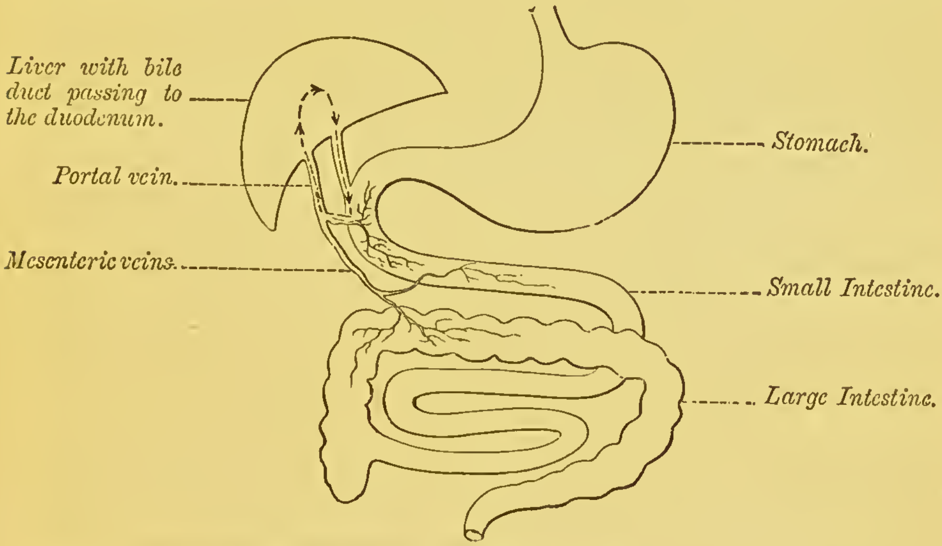

Fig. 4.—Enterohepatic circulation. The broken line - -> shows the absorption and re-excretion of bile.

But even this is not all. The liver actually destroys some organic poisons, such as nicotine; and, were it not for the faithful performance of its duty, we would be in danger of poisoning by every meal we take. For Ludwig and Schmidt-Mülheim have found that peptones, when injected into the general circulation, act as poisons, producing loss of coagulability in the blood and great depression of the circulation. We see, then, that the products even of healthy digestion might prove fatal if they passed rapidly into the general circulation; and it is still more likely that such an effect would follow the absorption of the products of the putrefaction which occurs in cases of indigestion. Were it not for this power of the liver to obstruct the passage of poisons, and actually to destroy them, the alkaloids formed either by normal digestion or by abnormal putrefactive process in the intestine might readily

pass to the heart, nervous system, and kidneys, and cause dangerous or fatal consequences.

The function of watching over the safety of the organism is not confined, however, to the liver, but is shared by other organs. The liver acts as a porter to prevent injurious substances passing from the intestine into the blood, but the tongue and palate are the porters, which prevent obnoxious substances from being taken into the intestinal canal. As a general rule, though by no means without exception, substances pleasing to the palate are useful and not injurious to the organism.

The nerves of taste, like those of sight and hearing, are nerves of special sense, and are capable of education. But, while we usually regard the education of the senses of sight and hearing as a noble thing, we are too careless of the education of our taste, and look upon it rather as something degrading.

Yet the education of the nerves of taste should be considered in the same light as that of the other special senses; and cookery has, I think, a perfect right to be ranked with music, painting, sculpture, and architecture as one of the fine arts. The difference between cookery and music, or painting, is, that while the objects which give rise to sight and sound remain outside the body, we are obliged to swallow the substances which excite sensations in our nerves of taste. It is not quite sufficient to turn them over in the mouth and put them out again, because the full sensation is only obtained just in the act of swallowing. For this reason devotees to the art of cookery must either be content with a moderate enjoyment of the pleasures of taste, or consent, like some of the Roman emperors of old or German students of the present day, to eject again the food or drink which they have already taken and enjoyed.

Only rarely does one meet with a dinner which gives one the sense of high artistic perfection, although I remember having partaken of one such when enjoying the hospitality of a City company. Each course seemed to excite an appetite for the one which succeeded, and was accompanied by a wine so carefully selected that it gave zest to the food, while the food appeared to give additional flavour to the wine.

This dinner was a revelation to me; it not only showed me that cookery might rank as one of the fine arts, but taught me that it might be a powerful moral agent. I went to the dinner exhausted with overwork, irritable in temper, and believing that City companies were wasteful bodies, who squandered money that might be

employed for useful purposes, and that they should be abolished; I came away feeling strong and well, with an angelic temper, and firmly convinced that City companies had been established for the express purpose of giving dinners, and ought on no account to be interfered with. Nor was the good thus effected of a transitory nature; the irritability of temper, which had disappeared in the course of dinner, did not return; and the morning afterwards, instead of awaking with headache and depression, I awoke strong, well, and ready for work, and remained so for a considerable length of time. Nor do I think that mine is a solitary case. A succession of heavy dinners is, no doubt, injurious; but when the organism is exhausted, a good dinner, with abundance of wine, is sometimes of the greatest possible use. But there is one condition which must not be neglected, or otherwise the consequences will be anything but satisfactory: the dinner must be well cooked, and the wines must be thoroughly good.

It is, as I have said, only occasionally that one meets with real high artistic cookery. But, even in the courses of an ordinary dinner, an order is adopted which is thoroughly physiological, and which shows that, whatever men may be in other things, they are not "mostly fools" in regard to the plan of their meals.

The common order of courses in a plain dinner is soup, fish, joint, pudding, bread and cheese, and dessert. The reason why soup comes first has been admirably shown by Schiff in his experiments on digestion. This physiologist found that the stomach of an animal which some time before had digested a full meal, had very little power to digest albumen introduced directly into it; and a similar fact was ascertained in regard to an extract made from the stomach itself, this extract hardly acting on albumen at all. The stomach seemed to be exhausted by the effort of digesting a full meal several hours before, and to be incapable of producing pepsine. But if certain substances were introduced first into the stomach, the power to digest albumen was enormously increased. To these substances Schiff gave the name of "peptogens," and the most powerful of them he found to be dextrin, and soup made from meat.

If the human stomach resembles the stomachs of animals in this point as it does in others, then we may say that usually the power of the stomach to digest such substances as hard-boiled eggs or boiled meat, when these are taken alone, will be very slight. But if the meal be begun with a plate of soup and a piece of bread, the bread which will be partly converted into dextrin in the mouth,

and the extractive matters of meat contained in the soup, on reaching the stomach will be absorbed, and will supply to the gastric follicles the power to secrete an abundance of pepsine. In this country, where our butcher's meat is tender and juicy, we not unfrequently find that people in the middle of the day will take a beefsteak or a mutton-chop without soup.

In this case, the savoury soluble substances which the meat contains are quickly extracted from it in the stomach itself, and, being absorbed, supply the necessary secreting power to the gastric glands. But in other countries, where the animals slaughtered for food are often old and tough oxen, which have been employed for years in agricultural service, the meat, being less savoury and juicy, will not yield peptogenic matters so readily to the stomach. Consequently, the Frenchman generally boils his butcher's meat thoroughly, and adds pieces of bread to the soup with which he begins his meal, so that the stomach can absorb sufficient peptogenic substance before the hard and tasteless boiled beef is swallowed.

Next to the soup, as I have said, usually comes fish, which is digested more easily than butcher-meat. I have already mentioned, more than once, that the rapidity with which anything dissolves depends very much on the fineness with which it is divided. Now, this is quite true of the different kinds of meat. Beef is acknowledged to be less digestible than mutton, and mutton less digestible than fish. The breast of a chicken is also reckoned very digestible. If we compare these different kinds of flesh, we will find that in beef the fibres are longer and harder than those of mutton, and those of mutton longer and harder than those of the breast of a fowl. The muscle-fibres in fish are arrayed in flaky masses, and are not only very short, but are very readily separated from one another.

We see, then, that the different digestibility of different kinds of meat corresponds exactly to the readiness with which their muscle-fibres can be broken up mechanically. That it is the physical conformation of the muscle-fibres, rather than anything peculiar to the animal from which they are derived, is shown, I think, by the fact that, although the breast of fowls is universally acknowledged to be readily digestible, the legs, in which the muscular fibres are long and hard, are by no means specially adapted for weak digestions.

With the meat, come vegetables, which are not only useful as supplying inorganic salts, but probably play a considerable part in

aiding the recomposition of peptones into the albuminous material of the tissues, after their absorption.

After the meat come the bread, cheese, and dessert. The bread will, no doubt, supply additional dextrin, and the cheese additional albuminoids; but, if we direct our attention only to the stomach, and to the chemical changes which are going on in it, it is not quite easy to see why bread, cheese, and dessert should be taken at the end of dinner. If we turn our attention, however, to the circulation and the nervous system, and remember the effect which I have already mentioned as produced upon them by the mastication and deglutition of savoury food, we can at once see a good reason for the common manner of terminating a dinner. In order to supply abundant gastric juice for the digestion of the food introduced into it, the stomach requires an abundant supply of blood, and the nervous system must be kept active in order to respond to the calls made upon it. The savoury cheese, swallowed in small morsels, and the sweet fruits, which strongly stimulate the nerves of taste, or nuts, which require considerable mastication, cause an abundant flow of blood to the nerve-centres; while the frequent movements of swallowing stimulate the heart, and increase the rapidity of the general circulation.

In the case of ordinary meals taken by a healthy man, the food is quite sufficient to stimulate the various parts of the digestive canal, the nervous system, and the circulation sufficiently to insure complete digestion. But if the meal be more than ordinarily heavy, if the person be exhausted by long fasting, by severe exertion, or have a weak digestion, other aid must be invoked. One of the most powerful stimulants, both to secretion and the circulation, is alcohol; and we find that persons of weak digestion sometimes take sherry and bitters before a meal, or take a glass of sherry with their soup. During the course of a meal, an effervescent wine like champagne is taken, the carbonic acid of which will stimulate absorption, while at the end a powerful stimulus is applied in the shape of a small glass of brandy or liqueur; and during dessert a quantity of wine is sipped, so that the effects already mentioned of the sipping upon the circulation and nervous system are combined with the action of the alcohol and ethers contained in the wine.

Provided that all those parts of a meal have been taken in moderation—and when we speak of moderation, we must always remember that this is a relative term: what is moderation for a

man of strong digestion is excess for a man of weak digestion—provided, then, that moderation has been exercised, no harm will result even from a heavy meal. But if the food has been excessive in quantity, or injurious in quality, and more especially if alcoholic stimulants have been taken in excess, the stomach will suffer, and, next day, the symptoms of gastric indigestion will probably appear. The most marked of these are: loaded tongue, loss of appetite, tendency to nausea, and, perhaps, even vomiting. The condition of the stomach, corresponding to these symptoms, was ascertained by Dr. Beaumont in the case of Alexis St. Martin. On looking into the interior of St. Martin's stomach, during the occurrence of such symptoms as these, Dr. Beaumont found "that several red spots and patches abraded of the mucous coat, tender and irritable, appeared over the inner surface." In such congested and irritable conditions of the stomach, the gastric juice secreted appears to have an alkaline, rather than an acid, reaction, and consequently to have comparatively little or no digestive power. The food will, therefore, pass from the stomach, not in the form of a fine emulsion, like chyme, but with undigested lumps in it, and these, irritating the intestine, will be not unlikely to produce diarrhœa; moreover, the intestine itself may also suffer by extension of the inflammatory condition, from the stomach along the mucous membrane. Then we notice, in addition to the sickness and nausea, those symptoms to which the term of biliousness is applied. The person is dull, heavy, and languid, disinclined to exertion, mental or bodily, irritable, or peevish, the complexion is muddy, and the conjunctiva is slightly yellowish, and perhaps there is more or less severe headache. All of these point to disturbance of the functions of the liver; but biliousness forms an intermediate link between indigestion and its consequences, so that the explanation of the different factors of biliousness must be reserved for the succeeding lecture.

LECTURE II.

INDIGESTION, BILIOUSNESS, AND THEIR CONSEQUENCES.

Delivered before the Medical Society of London, January 19th, 1885.

BILIOUSNESS and indigestion are terms which we use so frequently together, and which are so intimately connected, that we do not always sufficiently distinguish between them. Yet it may be worth our while to inquire where the one begins and the other ends, and to ascertain, if we can, what the nature of their connection is.

The condition which we term biliousness is, in all probability, of complex origin. Its name points to the liver as its source, while its close connection with disturbances of the stomach might lead us to ascribe a gastric origin to it. The difficulty we have in ascertaining the exact causation of biliousness is no doubt largely due to the fact that disturbance of the liver affects the stomach and intestines, and disturbance of the stomach and intestines affects the liver. Indigestion and biliousness are, therefore, so closely associated in many cases, that we can hardly say where the mischief began unless we can trace it from the commencement, although in other cases we get a clue to the primary origin of the disease by noticing whether the disturbance of function is greater in the stomach or in the liver.

The close connection between the liver, on the one hand, and the stomach and intestines, on the other, is rendered inevitable by the arrangement of the blood-vessels in them.

On looking at the liver, on the one hand, we see that, with the exception of a small quantity which passes through collateral branches, all the venous blood returning from the stomach and intestines must pass through the liver before it reaches the general

circulation (Fig. 4). Thus, any products of imperfect digestion are likely to affect the hepatic functions, and not improbably to derange them.

On looking at the stomach and intestines, on the other hand, we see that any hindrance to the flow of the portal blood through the liver will tend to cause venous congestion in them.

Fig. 5.—Diagram of the veins forming part of the portal circulation. The pancreatic and splenic veins, although most important, have been omitted for the sake of clearness.

On looking at the liver in a *post mortem* examination, it seems so hard and firm that we are apt to think that it is not capable of much dilatation and contraction in the living body. But this notion is perfectly erroneous. I have made a number of experiments on the artificial circulation of blood through the livers of

rabbits, and have been quite astonished to find what an elastic organ the liver is. When the bottle containing the blood was raised two or three feet above the liver, so as to increase the

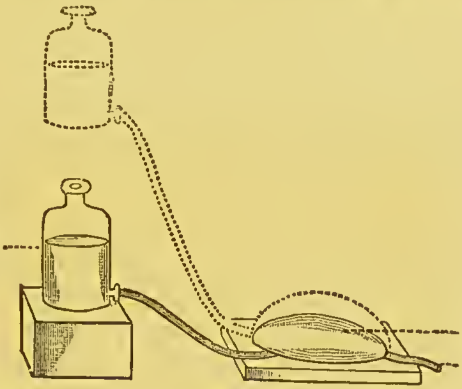

Fig. 6.—Diagram to show the effect of artificial circulation of blood through the liver, under different pressures. The continuous lines indicate the size of the liver, and the arrangement of the apparatus during circulation, under a low pressure. The dotted lines indicate the increased size of the liver, and the arrangement of the apparatus, with a high pressure.

pressure under which the blood flowed through it, the organ expanded almost like a sponge, and again contracted when the pressure was diminished. We do not usually notice any very great differences of size in healthy livers; but the reason of this, no doubt, is that the pressure of blood in the portal vein is very low, and not liable to great fluctuations.

But there was another point which struck me greatly in my experiments. Sometimes the blood would flow very easily through the liver, would, indeed, pour out from the hepatic vein in a full stream, as if no obstacle whatever had been presented to its flow through the hepatic capillaries. At other times, however, the flow would be slow and scanty, the blood evidently meeting with great resistance in the capillaries. These two conditions were sometimes found in the same liver at different periods of the experiment, and they appeared to depend to a considerable extent upon the quality of the blood which was circulating.

Bearing in mind this power of the liver to obstruct the circulation through it, we can readily see how a vicious circle may be formed: indiscretion in eating or drinking disturbs the digestive processes in the stomach and intestines; the products of imperfect digestion or of decomposition in the intestine being absorbed into the veins pass to the liver; they may there induce an obstructed flow through the hepatic capillaries; the venous blood returning

from the stomach and intestines will no longer be able to find an easy passage into the general circulation, and venous congestion of the stomach and intestines will be the result. Such venous engorgement as this will interfere with gastric and intestinal digestion, and this again will react upon the liver. Here, then, is a vicious circle which it is necessary to break. It may be broken in two ways: (1) by fasting, so as to allow time for matters to right themselves; or (2) by the use of medicines, as we shall afterwards see.

In order to form a clearer idea of what is actually going on in biliousness, it may be well to take advantage of that fortunate accident by which Dr. Beaumont was enabled to examine the interior of Alexis St. Martin's stomach, and discover what was going on there. Although some authorities have denied that the state of the tongue is any index of the condition of the stomach, this is not borne out by Dr. Beaumont's observations, for he found that the state of the two corresponded pretty closely. A healthy tongue is of a pink colour, it is very slightly rough, and its surface is moist. The mucous membrane of a healthy stomach is of a pale pink colour, it has a slightly rough velvety appearance, and its surface is merely lubricated by a thin layer of mucus. When it is stimulated by the ingestion of food, the vessels dilate, the colour becomes heightened, and the gastric follicles secrete a clear transparent juice, which goes on accumulating, and trickles down the sides of the stomach. From experiments upon animals we know what changes irritation of the gastric mucous membrane will produce. A *slight stimulus,* as already mentioned, causes the circulation in the mucous membrane to become increased, and gastric juice to be abundantly secreted. This effect may be produced not only by the ingestion of food, but also, though to a slighter and more limited extent, by gently rubbing with a glass rod or feather. But if the stimulus be *excessive,* e. g. if the rod be rubbed roughly instead of gently over the mucous surface, an entirely different result occurs; the vessels, instead of dilating, contract, the stomach becomes paler, and a quantity of mucus is secreted. If irritation be carried still further, the animal shows signs of nausea, and may actually vomit.

In indigestion and biliousness we find several stages upon which the experiments just mentioned throw considerable light. In the first the appetite is increased rather than diminished; in the next stage the appetite fails; and in the further stage nausea or vomiting

occurs. Even in the first stage, however, it not unfrequently happens that though the appetite is craving at first, a few mouthfuls of food are sufficient to satisfy it, and sometimes the appetite disappears merely at the sight of food, and is succeeded by nausea. In this case it is evident that the increased circulation in the stomach due to the introduction into it of food, or perhaps of the saliva excited by the expectation of food, has caused the condition of the mucous membrane to pass from the stage of slight to that of violent irritation.

Let us now see what conditions of the stomach correspond to these symptoms. Dr. Beaumont mentions that on one occasion St. Martin's tongue had a thin whitish fur, and the appetite was craving. On examining the stomach, several red spots and patches abraded of the mucous coat, tender and irritable, appeared spread over the surface. The digestion, too, was slower than usual, and seven hours were required for the gastric digestion of his dinner, instead of four and a half or five hours as usual. In this condition we cannot say that the liver is involved. The stomach is the only organ affected, and the disturbances of its functions are as yet but slight. Here we may say there is indigestion but not biliousness.

Two days afterwards, the indigestion had advanced further and the symptoms of biliousness had become superadded. His usual appetite was gone, the tongue was covered with a thin coat, no longer whitish but yellowish, the countenance was sallow, and on the interior of the stomach there were several deep red patches. A muslin bag which had been introduced with some food in order to test the rapidity of digestion, when drawn out was covered with a coat of mucus and yellow bile. The sallowness of the face, which had now appeared, may be taken as an indication that the liver had become affected, and that biliousness as well as indigestion was now present.

On the succeeding day the coats of the stomach were still unhealthy and of deeper red than naturally, with patches of a still deeper colour, and the mucous covering abraded in places. This deep colour indicates venous congestion and stagnation of blood, and is as different from the increased rosiness consequent upon the arterial dilatation and rapid circulation in healthy digestion, as the dusky hue in mitral disease is from the rosy flush of healthy exercise. This venous congestion indicates, I think, that the liver circulation is already becoming impeded, and that the impeded circulation through it is beginning to tell on the venous

radicles of the portal system in the stomach, and probably also in the intestines. At this time the secretion of gastric juice was very scanty, and the digestion slower, as well as less perfect than usual.

In this instance, the indigestion seems to begin in the stomach, and involve the liver secondarily; but I am inclined to think, although it is difficult to prove, that there are some instances in which the indigestion may begin in the liver, and involve the stomach secondarily. Such cases I think are met with amongst persons who suffer from malaria. The malarial poison, whether it be a bacillus or not, appears to have a particular power to affect the liver, spleen, and vaso-motor centres. Under its action, the liver may sometimes swell up enormously, and I am inclined to think that it frequently causes an obstruction to the portal circulation, even when the general circulation is unaffected. In such cases, we may expect to find such symptoms of indigestion as would be likely to occur from venous congestion; and this I think is actually the case.

The usual symptoms of indigestion are flatulence, weight in the epigastrium, acidity, and pain; and it may be worth while to try and ascertain the conditions to which each of those symptoms is due.

First of all, let me take flatulence. Flatulence is due to the presence of gas in the stomach and intestines, which sometimes rolls about, producing borborygmi, or escapes upwards or downwards, producing eructations or crepitations. If the pyloric orifice be closed, the gas from the intestine will not escape into the stomach, nor gas from the stomach into the intestine; but if the pylorus be open, gas may pass freely from the stomach into the intestine, and *vice versâ*. An analysis of gas from the stomach shows that it consists to a great extent of nitrogen and carbonic acid, in much the same proportion as the nitrogen and oxygen of air. It is therefore probable that most of the gas in the stomach consists simply of air which has been swallowed, but from which the oxygen has been absorbed into the blood, and has been replaced by a corresponding quantity of carbonic acid. We are very apt to forget that, although the mucous membranes in man are much specialised, so as to perform a particular function most efficiently, yet their power is not entirely limited to the one function. The diffusion of oxygen and carbonic acid just mentioned through the walls of the stomach, shows us that the gastric mucous

membrane has, though to a very slight extent, a respiratory action; and it is possible that other gases may be absorbed, though to a slight extent, by the gastro-intestinal mucous membrane. Indeed, I need not say it is probable, because we know for a fact that sulphuretted hydrogen may be absorbed in this manner. Some authors consider that the gastro-intestinal mucous membrane may secrete gas in large quantities. However this may be—and I think that it does not occur very frequently—it is probable that an interference with the absorption of gases may be a not unfrequent cause of flatulence.

In patients who suffer from malaria, attacks of indigestion are sometimes preceded, for two or three days, by a tendency to flatulence, without any other symptom. This may simply be due to disturbance of the stomach and intestines alone; but still I am inclined to think that, in these cases, the disorder begins in the liver, and not in the stomach; the portal circulation becoming obstructed first, and the gastric mucous membrane becoming congested secondarily.

After violent exertion, such as quickly running upstairs or trying to catch a train, one may observe that, at the same time that the heart is palpitating rapidly, and the breathing becoming short and difficult, there is a great tendency to flatulence. A similar condition is also found in patients with cardiac disease, and my friend Dr. Mitchell Bruce has called my attention to the frequency with which such patients complain of "heart-wind."

Another source of flatulence is the gas given off from the food in abnormal processes of decomposition. In cases of chronic gastric catarrh, for example, the secretion of gastric juice in the stomach is deficient; the food is digested slowly; the secretion, instead of being acid, is nearly neutral, or perhaps even alkaline; and fermentation may occur with evolution of gas. It is evident, however, that a considerable time is required to allow gas to be formed in any large quantity in the stomach: and therefore flatulence from this cause will not occur until some time after food has been taken, unless the pyloric sphincter be inactive. If the pylorus be open, gas may pass from the intestines into the stomach, and distend it; and such distension may occur at any time of the day or night, and is not necessarily dependent on the decomposition of food in the stomach.

I am inclined to think, however, that the most frequent cause of flatulence in the stomach is excessive swallowing of air. There is

little doubt that boluses of food may be swallowed without air; but some fluids, especially those of a tenacious character, such as pea-soup and saliva, appear to carry down a good deal. Moreover, it appears to me that, when a small quantity of saliva is swallowed at a time, it does not completely fill the pharyngeal cavity, and that air is actually swallowed along with it. This does not matter—probably it is even beneficial—if it be not carried on to too great an extent. But we can easily see that, if a person goes on swallowing air after a meal is over, or in the intervals between meals, flatulent distension of the stomach may readily be produced. The conditions which give rise to frequent swallowing of air, so far as my observation goes, are—(1) a continued flow of saliva into the mouth; (2) a sense of irritation or tickling at the back of the throat; (3) a feeling of acidity in the stomach; and (4) a feeling of weight or oppression at the epigastrium or across the chest. I mentioned before that stimulation of the stomach produced reflex secretion of saliva; and, if the mucous membrane is irritable, the secretion of saliva may go on long after it ought to cease, and give rise to frequent swallowing and accumulation of air.

Acidity in the stomach causes frequent swallowing, perhaps because the discomfort is momentarily relieved by the alkaline saliva as it passes from the œsophagus into the stomach. A feeling of oppression or constriction across the chest, like a huge iron hand clutching it, is due to irritation of the vagus, as we know from Czermak's experiments. He had an exostosis on one of his cervical vertebræ, and, by compressing the vagus nerve between his finger and this exostosis, he could stimulate it so strongly as to stop his heart. Such stimulation produced also a feeling of constriction, or, as it is well called by the Germans, of *Beklemmung*. But irritation of the vagus can be produced in other ways than by compressing its trunk. Depressing emotions, such as sorrow, appear to act on the nerve-centre in the medulla, from which the vagus springs, and it may be stimulated reflexly from many parts of the body, and notably from the stomach. As Kronecker has shown that its action over the heart is temporarily abolished by the act of swallowing, we would naturally expect any one suffering from the feeling of thoracic oppression or constriction due to irritation of the vagus would swallow frequently, in order to obtain relief. This appears to take place when irritation of the vagus, with consequent oppression of the chest, are caused by grief, so that it has come to be popularly expressed in the phrase "swallowed his

grief." So far as my observation goes, frequent swallowing also occurs in cases where thoracic oppression seemed to me to be due to reflex irritation of the vagus from the stomach.

Flatulent distension of the intestines may also be produced by excessive swallowing of air, and provided the pylorus be open, so that the air can pass through it, either temporarily, as when the contents of the stomach are passing out, or permanently, as in pyloric dilatation or paralysis. The enormous distension of the bowels in hysterical cases, and the rapidity with which it occurs, has often been a puzzle to medical men, and has led some to think that the only possible explanation is a rapid evolution of gas from the blood. From the observations of Ebstein and Zeckendorf,[1] however, it seems more probable that the true cause of this enormous dilatation is to be sought in a paralysis of the pylorus which allows the air to pass freely from the stomach into the intestines.

But whilst the air which has been swallowed is probably the chief agent in the production of gastric flatulence, the gases formed by decomposition in the intestine constitute the chief factor in cases of intestinal flatulence. They are found, on chemical examination, to consist of nitrogen, but in smaller proportion than the gas of the stomach, of hydrogen, of marsh-gas, and of carbonic acid; sometimes, also, there is a certain quantity of sulphuretted hydrogen. Some kinds of food are extremely apt to give rise to flatulence, and an analysis of Kolbe and Ruge[2] of the gases passed *per anum* by a man after different kinds of food, seems to show that it is the formation of marsh-gas which gives chiefly rise to the flatulence. The proportion of marsh-gas in their analyses amounted to a mere trace only, on milk-diet; to 27·5 per cent. on a flesh-diet; but it rose to no less than 55·9 when peas had been used as food.

Marsh-gas can only be formed in the absence of air, and so it is not produced in the stomach. It is sometimes, however, passed in eructations. C. Anton Ewald[3] had a curious case under his care, in which the patient was astounded to find, on trying to light a cigar, that inflammable gas was issuing from his mouth. Here, however, there can be little doubt that the marsh-gas was formed in the intestines, and passed through the open pyloric and cardiac orifices into the mouth.

Sulphuretted hydrogen is a product of the decomposition of

[1] *Pathogenese der Bauchtympanie Inaug. Diss.* Gottingen, 1883.
[2] Quoted by Landois. *Text-book of Human Physiology.* Translated by Stirling, p. 372.
[3] Reichert und Du Bois-Reymond's Archiv., 1874, p. 217.

albumen, and its odour is well known as that of rotten eggs. Although it is usually found in mere traces, if at all, in the intestine, it may sometimes occur in such quantity as to make the eructations very unpleasant, not only to the patient himself, but to his friends. When such eructations occur persistently, they are generally indicative of serious organic disease.

Another symptom of indigestion is acidity, and this is not unfrequently combined with flatulence. In some cases, as in that curious one of Ewald which I have mentioned, it may alternate with flatulence. As his patient expressed it, "sometimes he had within him a vinegar-manufactory, and at other times gas-works." The difference between these two conditions probably depended on the nature of the fermentation which was going on. As I have said, however, they are frequently associated, and I am inclined to think that a feeling of acidity frequently gives rise to flatulence, because the irritation which it causes in the stomach leads to frequent swallowing of saliva and air.

I have said purposely "a feeling" of acidity, because all cases of acidity do not depend, as is often imagined, on an increased proportion of acid in the contents of the stomach, but upon increased sensitiveness of the stomach or œsophagus, or upon some abnormal condition of the cardiac orifice, which allows the contents of the stomach to come more persistently into contact with the œsophageal mucous membrane than they ought to do. The œsophagus is much more sensitive than the stomach, as any one of you can easily discover for himself. If you will only swallow a bit of hot potato, you will be able to trace its progress right down the œsophagus to the pit of the stomach, and you will be able to ascertain precisely where your cardiac orifice is situated, because at that point the burning heat of the potato ceases to be felt as it drops into the stomach. Now this very point where the hot potato ceases to be felt, is the point where the feelings of acidity and heartburn are felt most strongly. A feeling of acidity coming on immediately, or very shortly, after a meal, is usually ascribed to increased proportion of acid in the gastric juice secreted by the stomach; while acidity coming on an hour or more after meals, is usually attributed to the formation of acid from the food by decomposition or fermentation.

There is no doubt that sometimes the contents of the stomach do become strongly acid from fermentation, and the matters vomited will not only burn the throat, but will set the teeth completely on

edge, just as drinking a mineral acid would do. The secretion of gastric juice containing an excessive proportion of acid is, however, by no means proven.

It is quite possible that the stomach might secrete an excessively acid juice, but Dr. McNaught[1] has shown in a recent paper that, although heartburn and acidity were present to an extreme degree in his patients suffering from irritative dyspepsia, in no case was the acidity above the normal. The same thing has been observed by Professor Talma[2] of Utrecht, who has shown that the feeling of acidity is really only a feeling by putting into the stomach of persons who suffer from it an artificial gastric juice containing only the normal proportion of hydrochloric acid, a proportion so small that, as is well known, it hardly gives an acid taste to the healthy tongue, much less excites any feeling of pain. In these persons, however, this dilute acid caused a feeling of acidity and pain. It is evident, then, that the feeling of acidity in cases of nervous or irritable dyspepsia, which is often great and very painful, which is usually associated with a clean tongue, and often occurs in gouty patients, is dependent upon hyperæsthetic conditions of the mucous membrane, and not upon excessive secretion of acid by the stomach. At the same time, we must bear in mind that there are other cases in which acidity is due, not to hyperæsthesia of the mucous membrane, but to increased formation of acid by the decomposition of food.[3]

The stomach is much less sensitive than the œsophagus, and usually irritation of the mucous membrane in the body of the viscus gives rise to a feeling of weight rather than of pain—a point which seems to indicate that the pain of heartburn is due to irritation of the cardia, and of the œsophagus, rather than of the stomach itself. It not only occurs just at the point where a hot potato ceases to cause discomfort on its way downwards, but occasionally heartburn may be brought on by certain positions, and relieved by others. Thus, it sometimes happens, that the contents of the stomach cause an acrid burning feeling in the epigastrium when the person is lying down, and especially lying

[1] McNaught, *Medical Chronicle*, January, 1885, p. 330.
[2] Talma, *Zeitschr. fur klin. Med.*, Bd. viii. p. 414.
[3] Since this lecture was delivered I have seen that Reichmann (*Berlin. klin. Wochenschr.*, Dec., 1884, p. 768) has found that gastric juice appears sometimes to be secreted with a larger proportion of acid than normal, but he also insists on acid dyspepsia being a neurosis due to hyperæsthesia.

on the back, but the feeling disappears when the upright position is assumed. It sometimes happens, also, that a little escape of flatulence from the stomach will cause the burning feeling to travel up the œsophagus.

Frequently, however, an escape of wind gives relief. It is difficult to determine, with certainty, what the cause of this relief is, but I am inclined to think that distension of the stomach by flatulence may tend to cause heartburn by pulling the edges of the cardiac end of the œsophagus apart, and thus exposing the sensitive mucous membrane to the action of the acid contents of the stomach. When the distension is lessened by eructations, the cardiac end of the œsophagus will close more completely, and thus protect the sensitive surface of the œsophageal mucous membrane and relieve the pain.

The stomach itself rarely contracts with such violence as to give rise to pain like that of colic, but it appears sometimes to do so, and then the pain is excessive.

The intestines are much more liable to spasmodic contraction, giving rise to the pain of colic.

Another consequence of indigestion, or, perhaps, rather I ought to say, of biliousness, is the occurrence of piles, which consist, to a great extent, of dilated hæmorrhoidal veins; and here, again, it is of great importance to remember that the blood from the intestines, as well as from the stomach, has to pass through the liver on its way to the general circulation (Fig. 4). No doubt some of the blood may return from the rectum by the middle and inferior hæmorrhoidal veins, without passing through the liver, but yet so much is returned through the portal vein, that any interference with the circulation through the liver will tell upon the veins of the rectum, as well as those of the other abdominal viscera.

In the fact, however, that part of the blood returns from the rectum, without passing through the liver, we see a new proof of the important function which the liver exercises in preventing the entrance of poisons into the general circulation. I have already mentioned that the liver has the power of excreting with the bile the poisons which have been absorbed by the portal blood, and also of destroying, to a certain extent, vegetable or animal poisons which are circulating through it. We would, therefore, expect that some of the vegetable alkaloids injected into the rectum would prove more fatal than when taken by the mouth, as they would be able to pass by the lower hæmorrhoidal veins

into the general circulation without passing through the liver. This actually appears to be the case, for Mr. Savory has shown that strychnine is more poisonous when administered by the rectum than when given by the mouth.

While a retarded circulation through the liver may give rise to discomfort, and even pain, by causing congestion of the stomach or intestine, or by giving rise to piles, it is not without its advantages to the organism; for it is in the portal blood and in the liver itself that the process of building up the smaller molecules of peptones and of sugar into the larger ones of globulins and glycogen takes place. If these products of digestion are absorbed in large quantity, and pass too rapidly through the liver, so that they reach the general circulation without undergoing sufficient elaboration, they may either prove injurious to the organism or be excreted as waste products, or both. Indeed, we find this to be the case, for we frequently meet with affections of the respiration, circulation, and nervous system, which actually seem to be due to a kind of poisoning by products formed, either in the intestinal canal itself, or in the blood; and we also meet with cases in which sugar, peptones, and albumen are excreted by the kidneys, instead of being applied to the repair of the tissues.

I have elsewhere insisted strongly on the distinction which is to be drawn between glycosuria from the mere presence of sugar in the urine and the disease diabetes.[1] Simple glycosuria may occur in perfectly healthy persons, and, indeed, is much more frequent than people generally believe. If you will examine the urine of several healthy persons a couple of hours after breakfast, it is highly probable that you will find distinct evidence of sugar; for breakfast is a meal at which a much larger proportion of bread is eaten than at other meals, and at which, not unfrequently, a good deal of sugar is taken along with tea or coffee. But glycosuria depending on digestion is a transitory condition, whereas the glycosuria of diabetes is permanent. That glycosuria occurring during the process of digestion and absorption, is due either to some alteration in the circulation in the liver, or else to the absence from the portal blood of bodies which will build up the sugar into larger molecules, appears to be shown by an observation of Lehmann.[2] He found that sugar, injected into the mesenteric veins of a rabbit, during digestion, does not appear in the urine,

[1] On Diabetes, Reynolds' *System of Medicine*, vol. v.

[2] Lehmann, *Akadem. Proefschr.*, Amsterdam, 1873.

although the same quantity, injected in the same way into a fasting animal, would produce glycosuria.

Within the last few years, the occurrence of temporary albuminuria has been shown to be much more frequent than was previously suspected. In some statistics of life-insurance drawn up in New York,[1] one out of every eleven healthy persons who applied for life-assurance was found to present traces of albumin in the urine. Some experiments made by Leube[2] on 119 soldiers showed that in 4 per cent. the morning urine contained albumin, and albuminuria occurred in less than 16 per cent. after a severe march. The proportion found by the American insurance-office is intermediate between the two values found by Leube. It is, I think, considerably higher than what one is accustomed to find in examination of persons proposing for life-assurance in London, but corresponds nearly to the proportion of cases of temporary albuminuria (12 per cent.) found by Parkes[3] in hospital patients.

The prognostic importance ofalbuminuria is very great, not only in regard to the question of life-assurance, but in regard also to the dietetic and hygienic treatment of the individual. If we were to assume that because albumin is present in the urine the individual is suffering from serious disease, we should fall into as grave an error as if we were to suppose that every patient whose urine contained sugar was necessarily suffering from diabetes.

As Dr. Warburton Begbie says, "it is surely a satisfactory consideration that a condition of excessive albuminuria—the urine becoming nearly solid on the application of heat and nitric acid—may, after all, not indicate the existence of any structural change in the kidney.[4]

In my first lecture, I insisted, at some length, upon the probable difference in the size of molecules, and mentioned that, whilst small ones diffuse through animal membranes, large ones will not. In the process of digestion, large albuminous molecules get split up into smaller ones, which become absorbed and then undergo reconstruction, being built up again in the portal blood, in the liver, and in the tissues, into larger molecules. The albuminous substances of the blood appear to consist of such large molecules that they will not diffuse through the glomeruli of a healthy

[1] *Medical Investigations in Life-Insurance*, United States Life-Insurance Company, 261, Broadway, New York.

[2] Salkowski und Leube, *Lehre vom Harn*, p. 369.

[3] *On Urine*, p. 187.

[4] Albuminuria in Cases of Bronchocele and Exophthalmos, *Edin. Med. Journ.*, April 1874; and Begbie's *Works*, Syd. Soc. Ed., p. 355.

kidney, but the products of digestion—peptones and hemialbumose—will diffuse through the glomeruli, and pass into the urine, producing peptonuria or hemialbuminosuria.

It would appear also that white of egg has a smaller molecule than serum-albumin, for white of egg, ijected under the skin, appears again in the urine, giving rise to pseudo-albuminuria, while serum of blood, or a solution of serum-albumin, injected in a similar way, causes no albuminuria. White of egg, when swallowed, does not usually pass into the urine as it does when injected subcutaneously, because it undergoes digestion in the intestinal canal, and is again built up after absorption into larger molecules. If taken in large quantity, however, some of it will escape digestion, will be absorbed unchanged, and will pass out through the kidneys and appear in the urine. I have tried the experiment by swallowing six raw eggs in succession. This quantity was insufficient to produce albuminuria, but it brought on such a violent headache and sickness, that I was deterred from ever making the attempt again. My friend, Dr. D'Arcy Power, who was making the experiment at the same time, succeeded in taking a sufficient number to produce albuminuria.

Coagulated albuminous bodies, such as boiled eggs or cooked meat, cannot be absorbed without being previously digested, and so are much less likely than raw eggs to produce albuminuria, even when taken in very large quantities. But, as I have already mentioned, the products of imperfect digestion, such as hemialbumose, behave in much the same way as egg-albumin, and may give rise to a form of albuminuria. Both egg-albumin and serum-albumin, when present in the urine, will cause a cloud on boiling, or on the addition of nitric acid; and yet it is obvious that the prognostic importance of the albuminous cloud, due to a dozen eggs swallowed one after the other, will be very different from that of an albuminous cloud due to degeneration of the kidney. It is, therefore, of great importance that we should distinguish between the different kinds of albumin present in the urine. This can be done, to a certain extent, by noting the point of coagulation, which is usually lower in the case of serum-albumin than it is in that of other albuminous substances. Time, however, will not allow me to enter further on this subject at present, and I have already discussed it elsewhere.[1]

[1] Lauder Brunton and D'Arcy Power, *St. Bartholomew's Hospital Reports*, vol. xiii. 1877, p. 283.

But while the mere occurrence of a little albumin once or twice in the urine is not to be regarded as of necessarily fatal import, it is not to be lightly passed over as a thing of no importance, even although the albumin should prove not to be serum-albumin, but only hemialbumose. Clinical experience had indicated a connection between long-continued digestive disturbance and organic disease of the kidneys, and this was experimentally demonstrated by Stokvis, who found that hemialbumose injected under the skin once or twice will pass out through the kidneys without doing them any apparent injury, but if the injections be frequently repeated, the hemialbumose in passing through the kidneys appears to excite in them organic disease.

Another disturbance of the urine connected with digestion is oxaluria. When we find oxalate of lime crystals in the urine, we must not at once conclude that the patient is suffering from oxaluria, any more than we must conclude that he is suffering from diabetes or Bright's disease, because we find sugar or albumin in the urine. It is not the occasional occurrence, but the more or less persistent presence of crystals of oxalate of lime in the urine, that is associated with a peculiar group of symptoms, of which the most prominent is perhaps mental depression. Oxalate of lime present in the food will be absorbed from the intestine, and a considerable proportion of it, at least, will be excreted again in the urine. We may thus expect that oxalate of lime would occur in the urine after stewed rhubarb had been taken for dinner, but there are other kinds of food which do not contain oxalate of lime, or only contain it in very small quantity, and yet give rise to crystals of oxalic acid in the urine. When I was house-physician to the late Dr. Hughes Bennett, a glass containing the patient's urine was invariably placed at each bedside, and in going round the ward in the morning, I used frequently to notice in the urine the hummocky mucous cloud, with its sharply-defined white top, resembling the woolly clouds in a summer sky, which is characteristic of oxaluria. On inquiry, I found that this appearance almost always resulted from the patient's having had cabbage for dinner the day before. Now, according to Esbach, cabbage is really singularly free from oxalic acid, and the oxaluria which it produced must be ascribed to some other cause than simple excretion of oxalate of lime taken in the food. The true cause, I have little doubt, is digestive disturbance; cabbage being one of those articles of diet which is exceedingly apt also to produce flatulence.

We do not know exactly how oxalic acid is formed, either in the intestine or in the body, and any observations regarding oxaluria must be to a considerable extent speculative. Thus, according to some, it is said to be due to the oxidation of uric acid, whilst others say that imperfectly oxidised uric acid splits into oxalic acid and urea. Others attribute it to incomplete oxidation of sugar, starch, and fat, in the food, or of non-nitrogenous fatty acids formed within the body; while others again say that it is entirely due to the re-excretion of oxalic acid taken in the food, and that no formation of oxalic acid in the body occurs at all. In the midst of these conflicting opinions, it is somewhat difficult to come to any conclusion, but it is worth while for us to note two facts, and see if there is any connection between them. The one fact is that pointed out by Esbach,[1] who denies the formation of oxalic acid in the body, viz., that if a reducing agent, such as sulphuretted hydrogen, be added to a strong solution of urates, crystals of oxalate of lime are at once produced.

The other fact, which we have already mentioned, is the tendency of cabbage to produce oxaluria, and also to give rise to flatulence, which probably depends, as it does in the case of other vegetables, on the production of hydrogen or marsh-gas.

These two facts may be connected by the following hypothesis, that as most plants of the order *Cruciferæ*, to which cabbage belongs, contain sulphur in unusual quantity, it is possible that this may give rise to sulphuretted hydrogen or sulphides in the intestine, which will act as a reducing agent, and tend to reproduce in the body the experiment which Esmarch performed in the test-tube.

In cases of imperfect digestion, not only are substances that ought to be used for the nutrition of the body excreted as waste, but products of the digestive process may act as poisons to various parts of the organism, and produce serious symptoms.

A common symptom of dyspepsia is shortness of breath, but in many instances this is merely of physical origin, the distended stomach pressing the diaphragm upwards, and interfering with the expansion of the lungs. There may be shortness of breath, also, which is of cardiac origin, the circulation being affected by the digestion in a manner which we will presently discuss. In addition to these different kinds of shortness of breath, however, we meet with actual asthmatic conditions, in which the entrance of air into

[1] *Journal des Connaissances Med.*, 1883, p. 155.

the lungs appears to be prevented by contraction of the involuntary muscular fibres surrounding the bronchi. The pathology of asthma is too little understood to enable us to say whether the bronchial muscles are made to contract by abnormal substances circulating in the blood, and irritating either the muscular fibres or their nerves; or whether the contraction is reflex, and is excited by a congested condition of the mucous membrane lining the respiratory passages.

There is another condition, however, namely, cough, which is frequently associated with indigestion—so frequently, indeed, that a kind of cough has come to be known as "stomach-cough." This popular name, though perhaps not scientifically correct, yet conveys a true impression. Cough is a reflex action. Reflex acts are generally adopted for a purpose. Cough is fitted to expel irritating substances from the respiratory, and vomiting from the digestive, passages. Irritation of the stomach will not of itself produce reflex coughing; the act corresponding to it is vomiting. Irritation of the respiratory passages, on the other hand, produces reflex coughing, and not vomiting. Nevertheless, it so happens that the action of an irritant, either in the digestive or pulmonary tract, may be aided by irritation elsewhere; and thus it happens that, when there is congestion of the pharynx and the upper part of the trachea, which is not in itself sufficient to produce coughing, the presence of any irritant in the stomach will assist this irritation in the respiratory passages, and coughing will occur. Thus I have observed a paroxysm of coughing coincident with acidity in the stomach, in a case where the fauces were much congested; and possibly also (although I did not make a laryngoscopic examination) the larynx and trachea may also have participated. This irritation was not in itself sufficient to cause coughing, but the additional irritation of the acidity in the stomach at once excited cough; and when the irritation was removed from the stomach by a dose of bicarbonate of soda, which neutralised the acid, the cough at once ceased. Now it is just at the pharynx—at the place where the respiratory and digestive tracts cross one another—that irritation is most likely to give rise both to coughing and vomiting; and this point, as we might readily expect, is one which is very readily affected by digestive disorders. I saw a very instructive case of this some time ago. A gentleman suffered from cough, which gave him a good deal of trouble; the back of his pharynx was congested, and I ordered him a gargle. For some time it was not a

bit the better, and then, for some reason or another, somebody else gave him several blue pills, and the cough disappeared (cf. p. 172).

The heart is very liable to be affected by digestive disturbance, and, like the lungs, it may be affected mechanically; for there is nothing between the heart and the stomach but the diaphragm; and when the stomach gets distended with gas, it may interfere with the action of the heart, and give rise to functional disturbance. This may evidence itself in faintness, in the shortness of breath which I have already mentioned, or in an intermittent pulse. The intermittent pulse, however, as well as the faintness, may be produced reflexly through the nervous system, instead of merely mechanically. Sensory nerves run from the stomach to the medulla oblongata, and, through these fibres, the heart may be reflexly affected. The resulting effects may differ according to the kind and amount of irritation; sometimes palpitation being produced from an affection of the acceleratory fibres, and sometimes a slow or intermittent pulse by an affection of the inhibitory nerves (*vide* pp. 148, 149).

It is quite possible that, in addition to the effect produced upon the heart directly and reflexly by the stomach, both the heart itself and the vessels may be influenced by substances absorbed from the intestine into the general circulation, and carried, not only to the heart itself, but to the nerve-centres which regulate both it and the vessels. We have not as yet, so far as I know, any distinct evidence of alkaloids having an action like that of digitalis or other cardiac poisons, being formed in the intestine, and passing from it into the general circulation.

We know, however, that alkaloids, having an action like muscarine, and having, like it, a powerful action on the heart and vessels, as well as on the intestinal canal, are formed by the decomposition of albuminous substances outside the body; and, in all probability, similar substances may be occasionally formed in the intestinal canal. It is probable that a microbe is the cause of cholera, but the symptoms occurring in the disease are probably due to the action on the tissues of a poison generated by the microbe, and not of the microbe itself, just as intoxication is due to the alcohol produced by the yeast-plant, and not to the action of the plant itself, on the nervous system and blood.[1]

An interesting question, on which the formation of alkaloids in

[1] For a fuller discussion of this subject, *vide* Researches relating to the Pathology and Treatment of Cholera, by Lauder Brunton and Pye-Smith, *Practitioner*, November 1884, *et seq.*

the intestine may throw some light, is, "What is the cause of sudden death in some gouty patients?" Such a case as the following is by no means rare. A hale old man, of a gouty family, has seemed unusually well, strong, and in good spirits. He eats an unusually hearty dinner, goes to bed, and is found dead next morning. In such a case, *post mortem* examination reveals nothing. The kidneys may be contracted, but the change in them has been of a chronic nature, and gives no clue to the cause of the patient's sudden death, unless it be that contracted kidneys will not excrete so quickly as healthy ones, and if a substance should be absorbed from the intestinal canal capable of acting as a cardiac poison, it will be more likely to cause death in a patient with contracted kidneys than in one with healthy kidneys.

But whether alkaloids which affect the heart are formed in the intestine or not, we have evidence that other alkaloids are formed which affect the nervous system very powerfully. In a paper which I wrote some years ago, I pointed out the great resemblance between the symptoms met with in indigestion, and in those in poisoning by curare. When an animal is poisoned with this substance, and the motor nerves begin to be paralysed, the increasing languor and difficulty of movement appear to strike the animal as strange, and it frequently looks at itself as if it were itself puzzling over its unwonted condition. The very same thing may not unfrequently be noted in cases of dyspepsia; an unwonted languor comes over the patient, generally about two hours after a meal, and the patient wonders why his limbs feel heavy, like lead, and why he should have such a disinclination to exercise, either bodily or mental. I may, perhaps, here be allowed to quote from the paper to which I have just referred[1] (*vide* p. 255), as the analogy which I then pointed out between the languor occurring in dyspepsia and curare poisoning has since received such remarkable confirmation, so that the languor would appear, from recent researches, to be due in both cases to alkaloidal poisoning.

"The feeling of muscular weakness and lassitude, which I have already had occasion to mention as frequently coming on about two hours after meals, is not uncommonly met with in persons belonging to the upper classes, who are well fed, and have little exercise. It is, perhaps, seen in its most marked form in young women, or girls who have left school, and who, having no definite

[1] Lauder Brunton, Indigestion as a Cause of Nervous Depression, *Practitioner*, October and November, 1880.

occupation in life, are indisposed to any exercise, either bodily or mental. I am led to look upon this condition as one of poisoning, both on account of the time of its occurrence, during the absorption of digestive products, and by reason of the peculiar symptoms, namely, a curious weight in the legs and arms, the patient describing them as feeling like lumps of lead. These symptoms so much resemble the effect which would be produced by a poison like curare, that one could hardly help attributing them to the action of a depressant, or paralyser, of motor nerves or centres. The recent researches of Ludwig and Schmidt-Mühlheim render it extremely probable that peptones are the poisonous agents in these cases, and an observation which I have made seems to confirm this conclusion, for I found that the weakness and languor were apparently less after meals consisting of farinaceous food only. My observations, however, are not sufficiently extensive to absolutely convince me that they are entirely absent after meals of this sort, so that, possibly, the poisoning by peptones, although one cause of the languor, is not to be looked upon as the only cause."

At the time when I wrote this, alkaloids had not been shown to be formed in the body, and I was inclined to attribute the languor to the poisonous action of peptones; but now the evidence which we have to prove the presence in the circulation of alkaloids formed in the intestine is just the same as that which we have to show their presence when injected subcutaneously. When curare is injected under the skin of a frog, we know that it has been circulating in the blood, not only because of the effects it has produced upon the motor nerves, but because, if we take a little of the frog's urine, we find that the poison has been excreted by the kidneys, and that the urine will produce symptoms of paralysis when injected under the skin of another frog. Now, Bocci[1] has found that, from human urine, an alkaloid can be extracted which possesses exactly the same action as curare. This alkaloid has not been shown as yet to be identical with the alkaloid obtained by Brieger[2] from the peptones formed by digestion of fibrin with gastric juice, to which he has given the name of peptotoxin. But whether these alkaloids be absolutely identical or not in their chemical constitution, they appear to be identical in their action, both acting like curare in paralysing the peripheral terminations of motor nerves.

[1] Bocci, *Arch. per le Scienze Med.*, vol. vi. No. 22, 1883.

[2] Brieger, *Ber. d. Deutsch. Chem. Gesell.*, xvi. pp. 1186 and 1405, 1883.

I have already insisted more than once on the function of the liver in arresting and destroying poisons which have been absorbed from the alimentary canal; and I have already pointed out that excessive bitterness is of the common characteristics of organic alkaloids. Now, there is a curious point about the bile which has, I think, not obtained the attention it deserves. "As bitter as gall" has come to be a household phrase, and we frequently notice that the bile vomited in cases of indigestion is very bitter indeed, so bitter as to be nauseous. But bile is not always bitter, as I once found to my astonishment when making some experiments with digitalis. I had taken nearly half a grain of pure digitalin on each of two consecutive days, and the poison began to produce, as one of its effects, very violent vomiting. During this, I brought up a quantity of matter resembling both in appearance and taste the yolk of a fresh egg, and perfectly destitute of bitterness. Not having eaten any eggs, I could not see what it could be but bile, but I was so very strongly impressed with the notion that bile was always bitter, that I did not put it down in my notes definitely as being bile, but only as yellow and liquid, somewhat like the yolk of an egg.[1] The absence of bitterness from freshly-secreted bile has also been observed by Mr. W. E. Green, of Sandown, in the case of a biliary fistula; and I am inclined to think that the bitterness which is supposed to be characteristic of bile does not really depend upon biliary constituents, but upon admixture with some alkaloidal substance derived from digestion. Some years ago, Dr. Bence Jones and Dr. Dupré showed that, in the liver and in other animal organs, an alkaloid was present resembling quinine in many of its reactions, and though, for some years past, their observation has fallen out of notice, it is beginning to acquire new importance, especially since it has been shown that quinine is very closely associated with phenol and other bodies of the aromatic group, some of which are formed in the intestine.

It is very curious to observe how views of all sorts seem to turn round and round again, though not so much in a circle as in a spiral, for at each turn they generally have advanced a little. For a long time the liver was regarded as a most important organ, and well it might be, for it is the largest gland in the body; and yet, for a while, it has sunk into comparative unimportance, its chief function being considered to be the secretion of bile. But to regard the liver in this light, is just about as rational as to think that an

[1] *On Digitalis, with some Observations on Urine*, p. 67. London: Churchill, 1868.

Atlantic steamer has been built for the express purpose of throwing out from its sides the two jets which are formed by the waste water from the engines. The condensed steam may be utilised, and so may the bile, but the condensation of steam is not the main object of an Atlantic steamer, nor is the secretion of bile the chief function of the liver. If we look at the liver, not as a mere secreter of bile, but as the organ in which probably the most important synthetical processes in the body go on, and in which the small molecules resulting from the digestion of food are built up into the more complex ones required to supply the waste of the various tissues in the body, we shall at once see a good reason for its enormous size, and for the important position which it occupies. If we recollect also its function as a porter to watch over the entrance into the circulation, and prevent the passage of noxious substances from the stomach or intestine, we shall readily understand how a slight disturbance of its function should give rise to such important functional alterations in other organs.

The Greeks showed their wisdom when they placed the seat of Hypochondriasis under the ribs, and when they connected depression of spirits with disorder of the liver by giving to it the name of Melancholy (μελας, black, and χολη, bile).

In her *Histoire de ma Vie,* George Sand says on this subject: "Whether it is the bile which has made me melancholy, or the melancholy which has made me bilious—this would resolve a great metaphysical and physiological problem, which I will not take up—it is certain that sharp pains in the liver produce symptoms in all those that are subject to them, of profound sadness and a wish to die. Since my disease first appeared I have had happy years, and when it seized me again, although I was in the condition most favourable to love of life, I felt myself suddenly seized by a desire for eternal repose." [1]

Sydney Smith describes in a very humorous way the connection between dyspepsia and low spirits. He says: [2] "Happiness is not impossible without health, but it is of very difficult attainment. I do not mean by health merely an absence of dangerous complaints, but that the body should be in perfect tune, full of vigour and alacrity. The longer I live the more I am convinced that the apothecary is of more importance than Seneca; and that half the

[1] *Histoire de ma Vie,* George Sand. Vol. xviii. p. 295. Paris: 1855.

[2] I am indebted for this to my friend Dr. De Havilland Hall, who showed it to me in Tanner's *Practice of Medicine,* 7th ed., vol. ii. p. 100.

unhappiness in the world proceeds from little stoppages, from a duct choked up, from food pressing in the wrong place, from a vexed duodenum, or an agitated pylorus. The deception as practised upon human creatures is curious and entertaining. My friend sups late; he eats some strong soup, then a lobster, then some tart, and he dilutes these esculent varieties with wine. The next day I call upon him. He is going to sell his house in London, and to retire into the country. He is alarmed for his eldest daughter's health. His expenses are hourly increasing, and nothing but a timely retreat can save him from ruin. All this is the lobster; and when over-excited nature has had time to manage this testaceous incumbrance, the daughter recovers, the finances are in good order, and every rural idea effectually excluded from the mind. In the same manner, old friendships are destroyed by toasted cheese, and hard salted meat has led to suicide. Unpleasant feelings of the body produce corresponding sensations in the mind, and a great scene of wretchedness is sketched out by a morsel of indigestible and misguided food. Of such infinite consequence to happiness is it to study the body." [1]

Usually, the melancholy and depression of spirits which are associated with disorder of the liver are attributed, like the bitter taste in the mouth, to the bile, which is circulating in the blood. No doubt, bile is a muscular poison; but we have already seen that the bitterness of bile is probably not inherent in the secretion itself; and there is, therefore, good reason for doubting whether the bitter taste in the mouth is due to bile. Moreover, we sometimes find the bitter taste with very little evidence of the presence of bile in the blood, the conjunctiva being, at most, only slightly tinged: whereas we sometimes see patients who are deeply jaundiced, and yet make no complaint of any such taste. For similar reasons we may regard it as probable that the depression does not depend upon biliary matters, but rather upon the noxious substances which have been able to pass through the liver and enter the blood.

We may regard, indeed, the association of bile with other noxious substances in the blood in very much the same way as the association of disagreeable smells with noxious properties in gases. The presence of a disagreeable smell often warns us of the presence of noxious gases; but these may occur in their most deadly form with

1 *A Memoir of the Reverend Sydney Smith*, by Lady Holland, vol. i. p. 125. London. 1855.

little or no disagreeable smell; and, on the other hand, we have disagreeable smells which are not associated with any danger.

As a rule people are now fully alive to the risks they run from poisoning by sewer-gas, or, to put it more widely, from poisoning by products of decomposition outside the body; but perhaps we do not all keep before us so clearly as we ought the fact that inside the body there are all the conditions for the formation of putrefactive products, and the most favourable arrangement for their rapid absorption. As the late Mr. Darwin once remarked to me, after reading my paper on Indigestion and Nervous Depression: "It is a wonder that we are alive," running, as we do, a constant risk of poisoning by the products of our own digestion. Slight poisoning does, no doubt, occur, and perhaps more frequently than we generally suspect. Severe poisoning is less common, but still may take place. One of the commonest constituents of sewer-gas is sulphuretted hydrogen; and Senator[1] described, in 1868, a most instructive case in which the patient became collapsed, and nearly died, with all the symptoms of poisoning by sulphuretted hydrogen generated in his own intestines.

A particular class of nervous symptoms, in which hypochondriasis and depression of spirits are accompanied by a deposit of oxalate of lime in the urine, has been thus described by Dr. Golding Bird: "The patients are generally much emaciated, excepting in slight cases, extremely nervous, painfully susceptible to external impressions, often hypochondriacal to an extreme degree, and, in very many cases, labour under the impression that they are about to fall victims to consumption. They complain bitterly of incapability of exerting themselves, the slightest exertion bringing on fatigue. Some feverish excitement, with the palms of the hands and soles of the feet dry and parched, especially in the evening, is often present in severe cases. In temper they are irritable and excitable; in men the sexual power is generally deficient, and often absent. A severe and constant pain, or sense of weight across the loins, is generally a prominent symptom, with, often, some amount of irritability of the bladder. The mental faculties are generally but slightly affected, loss of memory being sometimes more or less present." [2]

But in this condition we find the same difficulty of attributing the symptoms to the presence of oxalate of lime that we found in ascribing the depression of spirits in biliousness to the presence of

[1] Senator, *Berlin. klin. Wochenschr.*, 1868, No. 24.

[2] Golding Bird, *Urinary Deposits*, 5th ed., p. 251.

bile in the blood; for, as Dr. Roberts[1] points out, "these symptoms may be present in typical completeness without oxaluria, and, conversely, oxaluria may exist in its highest intensity, and even go on to the formation of a mulberry calculus, without evoking any of the above-mentioned symptoms."

In this condition then, as in biliousness, we are almost forced to ascribe the symptoms to the presence of some poison, of whose presence in the blood the oxaluria in one case and the yellowness of the conjunctiva in the other are merely indications.

The irritability which occurs in gouty persons is another example of nervous disturbance due to the presence of injurious substances in the blood, and their action upon the nervous system. But this has been already so graphically described by Murchison in his book on *Diseases of the Liver*, that I must refer you to it, and to the classical work of Garrod, as the subject is too wide to enter upon here.

There is only one so-called minor ailment connected with digestion which I will mention now, and that is headache. As I have pointed out elsewhere,[2] headaches are usually dependent either upon the presence of decayed teeth, or of some irregularity in the eyes, more especially inequality of focal lengths between the two eyes, or astigmatism. The site of headache depending upon decayed teeth varies with the teeth affected. The headache depending on inequality of vision is frequently frontal or occipital, although it may also be temporal (*vide* p. 105).

I am at present uncertain regarding the precise way in which indigestion produces headache; but I may remark that, as a rule, in headaches of this sort, the upper surface of the eyeball will be found to be excessively tender, and that the tension within the eyeball itself appears to be increased, so that sometimes the eyes feel like marbles or metal bullets under the finger when they are pressed. Another curious point that I have observed regarding headaches is that, as persons who are subject to them in their youth grow older, bilious headache is very apt to be replaced by giddiness; and that this change occurs about the time when the eyes are beginning to get a little hypermetropic, and the person begins to find the need of spectacles for reading.

[1] Roberts, *Urinary and Renal Diseases*, 3rd ed., p. 79. London: Smith, Elder, and Co.

[2] Headache, Neuralgia, and other Nervous Diseases connected with the Teeth, *Transactions of the Odontological Society of Great Britain*, 1880; and on the Pathology and Treatment of some Forms of Headache, *St. Bartholomew's Hospital Reports*, vol. xix. p. 399, 1883.

LECTURE III.

PREVENTIVE AND CURATIVE TREATMENT OF DIGESTIVE DISORDERS.

Delivered before the Medical Society of London, February 2nd, 1885.

In my first lecture, I mentioned that the function of digestion, like health generally, may be strong or weak. A strong digestion is capable of withstanding all sorts of adverse influences, while a weak digestion can remain undisturbed only under the most favourable circumstances.

When any disturbances have occurred in the digestive function, no matter whether it were strong or weak originally, the first step towards restoring it to health is to remove, if possible, any disturbing causes which may still be acting upon it.

One of the commonest of these is imperfect mastication. As I have said several times already—but the importance of the subject will excuse the reiteration—the first step in the process of solution is mechanical disintegration. Children are not long in learning this truth, for they soon find out that they get a fuller flavour from a hard sweetmeat if they break it with their teeth, than if they simply suck it. The child thus gets the sweetmeat quickly dissolved, and its sense of taste is more thoroughly gratified, but the sweetmeat does not remain so long in the mouth. If children of an older growth would remember this early experience, and apply it to their food generally, there would be less indigestion.

Man is a low-pressure engine, and works almost all his organs considerably under their full power. All around us in a town or city we see men who, in a walking tour, could do twenty, thirty, or forty miles without the least inconvenience, and yet in their

ordinary avocations they probably do not walk two. In the country, on the other hand, we find men of good brains, who have perhaps distinguished themselves at college by their mental powers, by their close application, and by the long hours during which they could work, and who yet in their daily life rarely set themselves a harder mental task than to understand the leading article of a daily paper. It is the same thing with the other organs of the body. A healthy stomach can usually digest a good deal more than it is called upon daily to do. A healthy kidney can excrete twice or thrice as much as it ordinarily does; and thus, in fact, we see that, when one kidney is removed, the organism frequently seems hardly to feel the loss, all the waste-products being excreted as usual.

But there is a limit to all things, and that limit is more easily reached in some cases than in others. As some one has shrewdly remarked, we have two kidneys and two lungs, but we have only one stomach, and therefore there is the greater reason why we should not overburden it. When a young man is called upon for extra exertion, either bodily or mental, he is able to meet the demand by making a spurt; but, as he grows older, this power gradually lessens. The same is the case with the stomach. Boys' stomachs can digest almost anything, though half-chewed green apples may sometimes prove too much even for them. In a youth, the stomach will digest the food even when bolted half-chewed; but, as the man approaches middle age, it resents this treatment; it will no longer make a spurt to do the work of the jaws as well as its own, and indigestion is the consequence.

Imperfect mastication frequently arises from too short a time being allotted for a meal, or from the mind being occupied during the meal with the idea of something to be done afterwards. It is curious sometimes to watch the phases of mastication varying in the same person during a single meal, according to the ideas which cross the mind. In some people, whenever the idea of something to be done occurs to them, motor energy seems to be evolved, and finds expression in rapid movements of the jaws and bolting of the food. It is, therefore, evident that, during meals, all ideas of action to be taken by the individual himself should be banished from the mind. In sensitive persons, also, it is well to banish the idea of action to be taken by others, because some persons have such strong sympathies that they throw their own personality into that of others, so that, if we watch them listening to a

hesitating speaker, we see their lips moving and their fingers twitching.

Persons who are taking their meals alone very frequently read during them. From what I have said, it is obvious that what they read at this time should not have reference to any of their avocations, nor even to anything which may interest them very strongly, such as politics, unless it be presented in an amusing form, as in *Punch*. But a solitary meal should be avoided if possible, for the mere presence of a companion, and, still more, occasional conversation, acts as a pleasant stimulus, and tends to maintain the nervous activity to which I referred in my first lecture as an important factor in perfect digestion.

Another cause of imperfect mastication is the condition of the teeth. Sometimes the teeth and gums are tender, or one or more of the teeth may be decayed, and the discomfort or pain occasioned in them by mastication leads people to bolt their food, or to masticate on the other side of the mouth, if the tenderness be limited to one side. But where this is the case, we not unfrequently find that several teeth have already been lost on the side with which such a person does chew, and that these teeth have been lost in such a way as to make the act of mastication a mere farce. When all the teeth are gone, the person may chew perfectly well, not only by means of artificial teeth, but also without them. One of the puzzles of my childhood was, how my grandfather, an absolutely toothless old man, was able to eat and enjoy hard toast. But every tooth in his head was gone, and his gums were like the mandibles of a turtle. It is not the complete, but the imperfect, removal of the teeth which is the source of mischief. We not unfrequently find that the teeth have fallen out in such a way that only one or two are left behind, which oppose one another so slightly that they are of very little use indeed for chewing, but they thoroughly prevent the gums from coming together, and leave large spaces in which the food can escape mastication completely. The remedy in such a case as this, is to get in false teeth; for few people, now-a-days, care to be absolutely without teeth at all.

But the effect, even of thorough mastication, upon the food will vary a good deal according to the nature of the food itself; and tough substances, which can with difficulty be comminuted, will be more indigestible than those which are readily broken up. Now new bread is proverbially unwholesome, and the reason for this is not far to seek. If we take a piece of a hot roll and try to

pulverise it between the finger and thumb, we find that it is more or less tough and tenacious, and that we can hardly do more than tear it apart into little bits. If we take a piece of stale bread, on the contrary, we can easily break it up into fine powder, which, of course, is much more readily acted upon by the digestive juices than lumpy flakes of new bread. Biscuits are also readily powdered; and crisp dry toast, although not so easily broken up between the finger and thumb, is still readily digestible, because it must be broken up by the teeth before it can conveniently be swallowed, for otherwise it would scratch the throat, although lumps of new bread of a similar size would slip down the œsophagus easily. Buttered toast is a different thing, as it cannot be readily pulverised, any more than new bread. Buttered muffins and suet dumplings are other examples of a similar kind to buttered toast. Potatoes are generally regarded as indigestible, and are forbidden to dyspeptics, whilst stale bread is allowed. It is possible that there may be other reasons for this indigestibility than simply difference of physical condition, but I have little doubt that one reason at least is the fact that very many people—indeed, I think most people—are apt to swallow potatoes in lumps without thorough mastication, and these lumps will be very slowly acted upon by the digestive juices.

The fine subdivision of fatty food is also of great importance in regard to its digestion. Many people cannot bear to eat the fat of hot mutton, but yet they can eat the same when it is cold. If we try to pulverise a piece of hot mutton-fat and a piece of cold mutton-fat we will see that the difference is much the same as that between a piece of new and of stale bread; and probably this is one reason, though there may be others, why hot mutton-fat is so liable to make people sick. But mutton-fat may be eaten hot by persons with delicate stomachs if it is properly subdivided by admixture with farinaceous food. If, for example, it be cut up very small, and mashed up with potatoes, even children may take it without difficulty, and mutton-fat and milk is an old-fashioned and useful remedy. The more minutely we can subdivide the fat, the more easily is it digested. I have already discussed this subject elsewhere, but it is of such practical importance that I may, perhaps, be allowed to repeat part of what I have said before (p. 9). If we were asked to take a pat of butter whole, the very idea of it might make us sick, but we have no difficulty whatever in taking the same amount of butter spread upon bread. Many

years ago, my friend Professor Hugo Kroneeker asked me the question, "How should butter be spread in a sandwich? should the whole of it be put on one sliee of bread, and the other sliee of bread simply put over the top of it, or should the pat of butter be divided into two halves, and one of them spread on eaeh pieee of bread?" I was uneertain how to reply. He answered the question himself, and said that "the butter should be divided into two halves, and one spread on each piece of bread, because, in this way, the butter is more minutely subdivided, and thus not only gives a more agreeable taste, but is more readily digested." In buttered toast, we get the agreeable taste from the minute subdivision of the fat, but the advantage obtained from this is more than counterbalanced by the difficulty in breaking up the toast, whieh I have already mentioned.

In regard to buteher's meat, also, there are great differenees, depending both on the kind of meat used and its eondition at the time of eooking. I mentioned in my first leeture, that meats which have short, easily disintegrated fibres, sueh as fish, the breast of a fowl, or mutton, are mueh more readily digested than those having long or tough fibres, such as beef. But a great deal depends, also, upon the condition of the meat at the time of cooking. I once got a most useful lesson on this point. I went into a restaurant, and ordered a beef-steak, as I had previously got them exceedingly good and tender at the same plaee. But that day, all my efforts to mastieate the steak were in vain, although I went on till my jaws aetually aehed with the exertion. On eomplaining to the waiter, and asking where he had got that tough old meat, he said it was not old, but, though young, it was too new. They had had an unusual number of eustomers that day; all the usual supply of beef-steaks had been eonsumed, and they had sent to the market for more, but had got back some meat killed that morning. Now, the old Romans, who were great epieures, used to eat still newer meat than this. They suffoeated their fowls in wine, and eooked them forthwith. We see, then, that meat is tender under two conditions—(*a*) when it is perfectly freshly killed, and (*b*) when it has been kept for a sufficient time. If we analyse these conditions, we see that the essential point in them is simply this: meat which is cooked before *rigor mortis* appears, or after it has passed off, is tender; but meat cooked while *rigor mortis* still exists is sure to be tough.

In the ease of game, the practice of keeping the meat until it is

tender has been overdone, and it is not unfrequently kept until it is actually commencing to decompose. The taste for "high" meat is an acquired one, and is, I think, a morbid one. It is also, I think, not without some danger, for not only may the products of decomposition formed in the meat, before it is cooked, be injurious, but decomposition will be rather apt to occur more readily in the intestinal canal. The gastric juice, no doubt, has a considerable antiseptic power, and so has the bile, but still these powers may be overtaxed, and eating high meat is one of the ways in which this may be done. It is, however, rather extraordinary to what an extent the consumption of decomposing food may be carried without any immediate injury, as we see amongst the Esquimaux and Icelanders.

The effect of keeping may, to a certain extent, be imitated by the application of a vegetable digestive ferment. In the West Indies, a tough beef-steak is rendered tender by rubbing it with the juice of a fresh papaw fruit, which contains a ferment, papain, having an action very much like the trypsin of the pancreas.

Another cause of imperfect digestion is, I believe, bad cooking. Even if we leave out of account the actual physical detriment to the food in the way of hardness, or toughness due to bad cooking, the absence of a pleasant flavour will in itself tend greatly to interfere with digestion.

The mere thought of agreeable food is sufficient to make the mouth water, not only in man, but in animals. I remember once seeing a striking instance of this. While walking one evening, I saw a dog sitting opposite the door of a butcher's shop, gazing intently at the meat inside. Two long strings of saliva were hanging down from its jaws, half-way to the ground. Its attitude of eager expectancy was so striking, that I could not help going into the shop to buy something for it; but it was sitting almost directly in the doorway, so that my passing through disturbed its delightful dream, and off it went.

We have already seen that the secretion of saliva is the first link in the chain of digestive processes. The saliva stimulates the secretion of gastric juice, and the gastric juice again stimulates the flow of bile, and possibly also of the pancreatic juice. Moreover, pleasant and repulsive food will act on the stomach through the brain; so that the idea of pleasant food will excite appetite, but the very idea of unpleasant food will excite disgust, and even bring on nausea and vomiting. Other things being equal, then, food

that is well cooked and savoury will be much more digestible than the same food cooked or served in an unappetising manner.

Even in regard to serving, there is much to be learned in this country from the French and Germans. In many a restaurant in London we find the table-cloths spotted and greasy, the salt-cellars and mustard untidy, the knives and forks dirty; and, as for a table-napkin, such a thing is in many of them unknown. In a French or German restaurant of a similar class, the table-cloth is very likely to be of coarser linen, but scrupulously clean; everything would be put down in a tidy and appetising fashion, and a clean napkin would be served to each guest. The food itself may be no better, perhaps not so good, but the way in which it is served would make all the difference to a delicate appetite.

In my first lecture, I spoke of cookery as a powerful moral agent, capable of influencing men's opinions and feelings to a very great extent. That food itself is a moral agent has been long recognised, and has found expression in the proverb, "A hungry man is an angry man;" but that the moral influence depends on the way in which the food is cooked, as well as on the food itself, is not so generally admitted. And yet it has long been known, for we read that Isaac directed his first-born son, Esau, to prepare savoury meat, such as his soul loved, so that, after he had eaten thereof, he might bless his first-born with all the fervour of which he was capable.

Considering the different effect upon the appetite of well cooked meat and of unsavoury food, it would be strange if they both excited equally pleasant feelings, and had an equally beneficial effect upon the temper.

Some may think that, in speaking of cookery as a moral agent, I am greatly exaggerating its power; and they may regard it as idle folly if I go still further, and say that cookery is not only a powerful moral agent in regard to individuals, but may be of great service in regenerating a nation. Yet, in saying this, I believe I am speaking quite within bounds, and I believe that schools of cookery for the wives of working men in this country will do more to abolish drinking habits than any number of teetotal associations. I do not at all mean to say that the vigorous efforts of teetotal societies, Good Templars, Blue Ribbon Army, and others, have been altogether a failure, but I do not think that their plan will ever be crowned with complete success, and I believe there is a better way of attaining their object.

Supposing you go to visit a friend and find him taking a wet pack. He is lying in bed, wrapped up in blankets so that he cannot move hand nor foot; a fly settles on his nose, and he begins making faces to try and remove it. You do not like to see him make faces, and wish him to stop. Which would be the most rational method of doing so? Would it be to exhort him to summon all his fortitude to keep his face still, notwithstanding the annoyance, or would it be better for you to drive away the fly? No doubt it might be an excellent moral training for him to use his self-control and keep his countenance placid notwithstanding the irritation, but the simpler and more effective method would be to drive away the fly. Moreover, in nine cases out of ten, his power of self-control would be insufficient; and this is exactly what occurs with persons who have a strong desire for intoxicating liquors.

Many years ago, I met, in a teetotal journal called the *Adviser*, with an account of an old drunkard, who uttered the bitter complaint, "The neighbours always speak of my drinking, but they never speak of my drouth."[1] The old man was in the right; and, if we are to abolish drunkenness, we must remove the thirst which leads to drink. I have discussed the causes, physical and moral, of this thirst more at length elsewhere;[2] and the only ones with which I shall concern myself now are bad food and imperfect cookery. In my first lecture, I mentioned that, so long as the food is only in the intestinal canal, it is still outside the body as far as nutrition was concerned; and thus the malnutrition which gives rise to a craving for alcohol may be a consequence of imperfect digestion, as well as of an insufficient supply of food.

I have spoken of food and of cookery as moral agents, but a clear-headed clergyman in New York has perceived that dentistry may be a moral agent, and he has insisted on all the people attending his mission-chapel keeping their teeth in good condition. If anyone has bad teeth, he is sent to a dentist, who fills or extracts them as may be needed. A dentist is supplied who does the work for nothing, if the patient cannot afford to pay. Since the clergyman adopted this plan, he has had very much less trouble from drunkenness in his congregation.[3]

The relation between the consumption of alcohol and the quality

[1] Scotch word for thirst.

[2] *The Influence of Stimulants and Narcotics on Health. The Book of Health.* London: Cassell and Co.

[3] The *New York Medical Record*, February 24th, 1883, p. 224.

of the cookery has recently been investigated in Switzerland, and it has been shown that, where the food is insipid and unappetising, the people have recourse to a glass of "schnaps" to make up for the deficiency.[1]

We have no experiments at present to show how savoury and unsavoury food, respectively, affect the circulation in the brain; but it seems highly probable that savoury has a much more stimulating action than unsavoury food on the cerebral circulation. I have insisted a good deal upon the important vascular changes which are produced by the act of swallowing, and these changes appear to afford an explanation of some curious phenomena. It is frequently stated that a glass of beer, slowly sipped, will intoxicate a man; whereas, the same quantity, swallowed at a draught, will have little or no effect. I do no not know how far this is true, but it is not the kind of statement that would be readily invented, so that I think there must be foundation for it in fact. We can easily see that the disturbance of the circulation, consequent upon frequent sipping, may so aid the effect of the alcohol that intoxication may ensue, although the alcohol alone could not have produced this effect. But, while frequent sipping may be thus used, on the one hand, to produce intoxication, it may be employed, on the other, in the cause of temperance. Some time ago, I saw in an American periodical a cure for drunkenness. The person was advised, whenever the craving came on, to sip a glass of cold water. At first sight, this may seem a poor substitute for a glass of whisky, and very unlikely to remove the craving for alcohol; but, as I have mentioned in my first lecture, a glass of cold water, slowly sipped, has more effect upon the pulse than a glass of brandy swallowed at a draught; and may therefore be a very efficient substitute, indeed, for alcoholic beverages.

To prevent any misunderstanding on this point, I should mention that the effect of sipping upon the pulse is not a permanent one; it lasts while the sipping is continued, if the sips be taken at short intervals; but it passes away after the sipping ceases. While its effect upon the pulse is thus greater for the time than that of alcohol, it is much less permanent. When I wrote my paper on "Nervous Depression as a Consequence of Dyspepsia" (p. 255), the effect of sipping upon the action of the vagus had not been discovered, but its stimulant action had been

[1] *Die Ernährungsweise der arbeitenden Klassen in der Schweiz. von Dr. Schuler.* 1884, Bern. Stämpflische Buchdruckerei.

observed clinically (I believe by Sir Andrew Clark); and I then recommended that a glass of soda-water, with or without the juice of a lemon squeezed into it, should be slowly sipped when the feeling of weakness came on, and a biscuit eaten along with it, if desired.

But, besides cooking and mastication, we have to consider a most important question—the kinds of food which a person may eat. In a healthy man, the best guide, both as to quantity and quality, is the appetite. Food that is eaten with a relish is, as a rule, wholesome; and sometimes it is rather astonishing to find how people's instincts guide them to what is suitable for them, in utter defiance of all *à priori* notions. As Dr. Austin Flint very sensibly puts it, "the diet should be regulated by the appetite, the palate, and by common sense."

Too great a regulation of the diet is sometimes very injurious; and this, I believe, is more especially the case in persons of a nervous temperament. I have already mentioned that some cases of acidity, and even of severe pain, do not depend upon any abnormal acidity of the gastric juice, nor of the contents of the stomach; nor yet do they depend upon any imperfection in digestion, for Leube has found that, in such cases, digestion is often performed very thoroughly and rapidly indeed. The pain in these cases depends upon hyperæsthesia; and, if the patient begins to cut down his diet, one article after the other may disappear, and the mischief will only become worse. The nervous system becomes more and more irritable as the blood becomes more impoverished, and the system may break down completely from inanition. In such cases, as I shall have afterwards to mention, forced feeding, or, as we may term it, stuffing the patient, is of the greatest possible service.

But, as Dr. Flint wisely puts it, the palate and the appetite alone will not serve as reliable guides to the quantity and quality of food. They must be regulated by common sense, or, in other words, by experience. We find this in the case of animals. A horse turned loose into a field of new clover may eat so much as to kill himself by over-distension of the stomach and intestines. A cow turned loose for the first time into a pasture in which colchicum, or other poisonous plants, grow, may eat of them at first, and be ill in consequence; but, after it has become acquainted with their injurious action, it will avoid them. The appetite which regulates the quantity of food, and the palate which regulates its nature, must both be trained; and we must also use

our experience, in order to make sure that we do not misinterpret their demands. When a person has been fasting for many hours, his appetite becomes ravenous, and he is apt to eat far more than is good for him. We are sometimes apt to treat ourselves as we occasionally treat others, and be in too great a hurry to gratify the demands of our own appetites, as well as to answer the questions, or grant the requests made to us by others. Solomon says of the man who hastens to reply to a question before he has fully heard it out, that, "it is a folly and shame to him," and the same is true of the way in which we sometimes treat our appetite.

I remember once hearing a story of a boy who stole a marble. On his mother chiding him and asking him whether his conscience had not told him not to touch the marble, the penitent culprit said: "No, mother, I grabbed quick." He had not given his conscience time to speak, and we frequently treat our appetites in like manner.

Let us take the ordinary case of a man who has breakfasted at eight in the morning, and has had nothing to eat till seven at night. He sits down with a voracious appetite, and gorges himself until he becomes semicomatose, and resembles a bloated boa-constrictor rather than a rational being; or else his overloaded stomach rebels, and a fit of violent vomiting and purging induces his relations to send in a hurry for their medical man, and urge him to come with the utmost speed, for So-and-so is dying of cholera. Yet the poor appetite was not to blame. The nervous system had been starved and wanted food; but, as I have already insisted more than once, food in the stomach is outside of the body for the purposes of nutrition, and requires to be absorbed before it is available for the wants of the organism. No doubt the stomach, as it became gradually distended, informed the brain, through its nerves, that food was on its way. But still, this was not sufficient, and the appetite remained unappeased. By the time enough food has been digested and absorbed to satisfy the cravings of the nervous system, too much had been put into the stomach to its detriment.

If, instead of hurrying the food down, the person had been content to eat slowly, with intervals between his courses, as, for example, if he had been put down to a *table d'hôte* abroad, the chances are that the dinner would have done him no harm, for the long intervals between the courses would have allowed some of the food first taken to be digested and absorbed long before the end

of the dinner was reached; and the craving appetite being thus lessened, the temptation to overeat would have been removed. Not unfrequently we hear people say that they are well when living abroad and dining at a *table d'hôte*, although the food that they get there is not nearly so good as what they get at home. The reason, in all probability, is, that they are obliged to spend more time over their meal, and are unable to swallow it down, or, as the Americans phrase it, "to get outside of it" so quickly as they can at home.

The remarks of Dr. Beaumont in regard to the question of appetite, as a regulator in eating, are so apposite that I shall quote them. Since they were written, medical opinion has passed to the opposite extreme from that which he denounces, and starving, rather than stuffing, has become the fashion. A reaction has set in against the starving system; but let us hope (although we can hardly expect) that it will not pass beyond the just views of moderation which Dr. Beaumont advocates. He says: "There is no subject of dietetic economy about which people err so much as that which relates to quantity. The medical profession, too, has been accessory to this error, in giving directions to dyspeptics to eat until a sense of satiety is felt. Now, this feeling, so essential to be rightly understood, never supervenes until the invalid has eaten too much, if he have an appetite which seldom fails him. Those even who are not otherwise predisposed to the complaint, frequently induce a diseased state of the digestive organs by too free indulgence of the appetite. Of this fact, the medical profession are, generally, not sufficiently aware. Those who lead sedentary lives, and whose circumstances will permit of what is called free living, are peculiarly obnoxious to these complaints. By paying particular attention to their sensations during the ingestion of their meals, these complaints may be avoided. There appears to be a sense of perfect intelligence conveyed from the stomach to the encephalic centre, which, in health, invariably dictates what quantity of aliment (responding to the sense of hunger and its due satisfaction) is naturally required for the purposes of life; and which, if noticed and properly attended to, would prove the most salutary monitor of health, and effectual preventive of disease. It is not the sense of satiety, for this is beyond the point of healthful indulgence, and is Nature's earliest indication of an abuse and overburden of her powers to replenish the system. It occurs immediately previous to this, and may be known by the pleasur-

able sensation of perfect satisfaction, ease, and quiescence of body and mind. It is when the stomach says enough; and is distinguished from satiety by the difference of the sensations—the former feeling enough, the latter too much; the first to be produced by the timely reception into the stomach of proper aliment in exact proportion to the requirement of nature, for the perfect digestion of which a definite quantity of gastric juice is furnished by the proper gastric apparatus. But, to effect this most agreeable of all sensations and conditions—the real Elysian satisfaction of the reasonable epicure—timely attention must be paid to the preliminary processes, such as thorough mastication, and moderate or slow deglutition. These are indispensable to the due and natural supply of the stomach at the stated periods of alimentation; for, if food be swallowed too fast, and pass into the stomach imperfectly masticated, too much is received in a short time, and in too imperfect a state of preparation, to be disposed of by the gastric juice." [1]

Appetite and palate have both their own work to do in regulating the quantity and quality of the food; but each of them requires, as Dr. Flint says, to be regulated by common sense, for otherwise they sometimes disagree, and the pleased and tickled palate sometimes endeavours to force down a much larger quantity of savoury food and delectable dishes than appetite declares to be either necessary or good for the organism. Sometimes the palate is tempted simply by savoury dishes at meal-times, but sometimes idleness adds to the temptation. Dr. Combe very sensibly remarks on this point: "But it is with idle people as with children. Leave them without occupation, and their chief amusement will then be derived from the indulgence of their appetites. Hence the prevalent pastime of forenoon visits to the pastry-cook's, where the appetite is indulged with as little regard to the real wants of the system, or the condition of the stomach, as if digestion were meant merely as an appendage to taste. Many young persons do themselves serious injury in this way, and then complain loudly of the discomfort which attends the subsequent indigestion of a heavy dinner. To relieve the weakness, arising not from exhaustion, but from the oppression of satiety, they resort to wine, as if, by adding fuel to the fire, they could reasonably hope to extinguish the flame." [2]

[1] Beaumont, *Experiments and Observations on Digestion.*

[2] Combe, *Physiology of Indigestion*, ninth edition, by James Coxe, M.D., 1849, p. 77.

When pushed beyond a certain point, the appetite rebels, and "the full soul loatheth the honeycomb;" but before this point is reached, a good deal more than enough may have been eaten; and if the same process be repeated every day, serious mischief will ultimately result, and the more accommodating the appetite is, the more serious will the mischief be. Many a man has been saved by a weak stomach, which punished its owner by sickness or headache whenever he tried to overburden it, and thus checked his tendency towards excess at the very outset. Where the stomach and intestines are more accommodating, and continue to digest all that is put into them, the burden of the work is shifted elsewhere, and either the liver fails to reconstruct the new material with which it is deluged, or the tissues are poisoned, and the overworked kidneys become degenerated.

The palate, like the appetite, sometimes makes demands which are apt to be misconstrued. As the late Professor Laycock observed, patients recovering from a severe illness not unfrequently have a strong desire for salt herrings, pork, or ham, things which would be almost certain to disagree with them if their appetite were indulged. But the fact is that the patients do not want the pork or herring; what they really desire is salt, and they crave for these articles because they contain salt. If salt be given to them in the form of a mixture, their appetite is appeased, and the harm is avoided which the herring or ham might have caused.

If we were to attempt to lay down a diet-table, containing all the things that a person, whether healthy or dyspeptic, may eat, the task would be endless; it is much simpler to say what he may not eat. The oldest diet-table in the world might have been a very long one if everything that might be eaten had been named; whereas it was very short—"Of every tree in the garden thou mayest freely eat, but"—and here follows the one exception, of which Adam might not eat without injury. The next diet-table is still more extensive, "Every living thing that moveth shall be meat for you, even as the green herb have I given you all things; but"—and here again comes the single exception—"the flesh with the life thereof, which is the blood thereof, shall ye not eat." In a third diet-table, intended not for mankind generally, but for people under peculiar conditions, we still find the same rule followed; the foods that were to be eaten being classed together under one or two sweeping definitions, and only a few exceptions mentioned by name. Dyspeptics may be regarded as a peculiar

class of people, requiring fuller instructions as to diet than healthy people, and a few general directions to them are by no means out of place. Thus, they may be directed to avoid new bread, buttered toast, muffins, and pastry, all of which are difficult to disintegrate, and sweets, which may undergo acid fermentation. They may be told to eat fish, or to prefer meat which has a short-fibre, like mutton, chicken, or game, rather than to take those meats where the fibres are long and tough, like beef.

There are some substances taken as food which are utterly indigestible. We know that prehistoric man was fond of strawberries, because the seeds of some, which a man, ages and ages ago, had eaten and voided unchanged, still remain to inform us of the fact. Most seeds, when whole, are indigestible; and on this quality, indeed, their distribution over the earth's surface depends. Even when broken, like the kernels of nuts or almonds, they are sparingly digestible; and the same is the case with the skins of fruits, and the harder fibres and the stalks of vegetables.

Where the intestines are slow to act, such things as strawberries, raspberries, figs, nuts, prunes, and apples, may be allowed, and even recommended; but, where the intestines are irritable, all such things must be forbidden. Acid fruits are not only indigestible in themselves, but are apt to leave irritation behind; and Dr. Beaumont found that, an hour after giving St. Martin some raw, ripe, sour apples, the stomach was full of fluid and pulp which was quite acrid, and irritated the edges of the fistulous opening, "as is always the case when he eats acescent fruits or vegetables." The acrid condition went on increasing to the end of an hour and a half, and, at the end of two hours, the mucous membrane appeared irritated, although the apple had passed out of the stomach into the intestine, probably in an undigested condition, and, as we know in other cases at least, it would then be apt to produce diarrhœa.

Some drinks are peculiarly liable to cause indigestion; amongst these are sour wines, some kinds of beer, and tea. Sour wines, especially if taken regularly, are apt to bring on a condition of gastric catarrh; and, in certain conditions of the system, a single glass even of good wine appears to act almost like poison. It seems to undergo acetic fermentation in the stomach, and produces acidity, discomfort, or pain. I do not know what these conditions of the stomach are in which a single glass of good wine will produce

this effect, even in persons to whom it is not usually injurious. I have noticed, however, that sometimes this tendency to acidity is associated with a hyperæsthesia of the mucous membrane of the œsophagus, so that port or sherry causes an unpleasant burning feeling all the way down the gullet, while usually nothing more would be felt than a pleasant warmth, if any sensation were observed at all.

Tea is very apt to cause a feeling of acidity and flatulence. Sometimes the acidity comes on so soon after the tea has been taken, that it is difficult to imagine that the feeling can be due to any actual increase in the acidity of the contents of the stomach. It seems much more probable that the feeling is due to some effect of the tea, either on the sensory or motor nerves of the stomach, or perhaps on its muscular fibres. Tea in the afternoon, two or three hours after lunch, will sometimes bring on acidity almost immediately; and I am inclined to think that this is due either to its producing increased sensibility of the gastric mucous membrane, or, what is perhaps still more probable, to its altering the movements of the stomach, so that the mucous membrane of the cardiac end of the œsophagus becomes exposed to the action of the contents of the stomach. These are much more acid two hours after a meal than they are immediately after it; and they will thus produce a much more irritating action upon a sensitive mucous membrane.

Tea contains a quantity of tannin, as we can readily perceive by the black spot which a drop of it will leave upon a steel knife, and it contains also caffeine and volatile oil. The effect of the tannin is to interfere very considerably with the digestion of fresh meat; and there are many people in whom tea, taken along with fresh meat, will upset the digestion. It does not interfere with the digestion of dried meat, such as ham and tongue; the fibres of these having already become shrunk and toughened in the process of curing.[1] Tea at breakfast is not so apt to cause indigestion, probably because bacon or tongue are more frequently taken along with it at this meal than fresh meat, and also because the long interval which has elapsed between breakfast and supper or dinner allows the stomach to become completely empty before any new food is put into it.

A part of the mischief wrought by tea in the lower classes is due to their allowing it to infuse for a long time, so that a large quantity of tannin is extracted. This danger may be avoided by

[1] J. W. Fraser, *Action of Infused Beverages on Peptic Digestion*, *Journ. of Anat. and Physiol.*, vol. xviii. p. 31.

simply allowing boiling water to stand in the tea-pot for five minutes or so, and then pouring it off into another tea-pot, where it may be kept hot for a length of time without undergoing any change. Another reason is that they drink it extremely hot. Heat is a powerful stimulant to the heart, and a cup of hot tea is, therefore, much more stimulating and refreshing than a cold one; for not only does the hot tea act more powerfully on the heart through the nerves of the stomach, but the heat will reach the heart directly through the thin diaphragm. The practice of sipping the tea almost boiling hot is, however, apt to bring on a condition of gastric catarrh.

Coffee does not affect the stomach to such an extent as tea. In its preparation, however, a substance called caffeon is produced; and this, along with the caffeine which is present in both coffee and tea, appears to dilate the abdominal vessels, and cause a feeling of fulness in the abdomen, with a tendency to piles in some persons.

Cocoa is less liable to cause acidity or abdominal discomfort than tea and coffee; but, when continued for some time, it is apt to give rise to those symptoms already described under the head of biliousness. In all probability, this depends partly on the amount of fat it contains, as cocoatina, from which the fat has been removed, is less likely to produce the symptoms than chocolate.

Another cause of imperfect digestion is fatigue. When we start on a walk, it does not matter much whether the road be rough or not; any little obstacle is avoided with ease, and we thread our way over rough stones, through tangled heather, or over a quaking bog, without difficulty. Our nervous system is in full vigour, and preserves perfect co-ordination amongst the movements of the different parts of the body; so that one helps the other, and all difficulties are surmounted. But when we are tired, the case is very different; a little roughness in the road will cause us to stumble, and an unexpected stone may give us a sudden fall. The wearied nervous system no longer co-ordinates the movements of the various parts of the body, so that they no longer work together for a common end.

The same thing occurs with the various parts of the intestinal canal. In my first lecture, I described the mechanism by which the acts of chewing and swallowing appeared to act as stimulants to the circulation and nervous system, and thus to ensure the

proper co-ordination between the functions of the mouth, stomach, intestine, and liver. But, if the nervous system be exhausted by previous fatigue, or debilitated by illness, the requisite co-ordination may not take place, and indigestion or biliousness may be the result. How often do we find that the meal taken by a person immediately after a long railway-journey disagrees with him, and either causes sickness, diarrhœa, or a bilious headache. Forty winks after dinner is by no means a bad thing; but forty winks before dinner is frequently much better. How often do men who have been working hard all day, with their mental faculties continually on the stretch, go home and have dinner forthwith. Exhausted as they are, how can they expect to digest properly what they eat? Almost the only saving point is, that many of them live some distance from their place of business, and have a short time during the homeward drive to sit still and rest. This is sufficient for some, especially for young men; but it is insufficient for elderly men, and they ought to make a point of having a little rest at home before dinner. Some men, unfortunately, are so misguided as to believe that exercise after a hard day's work will do them good; and, instead of utilising the little time they have for rest after a day's labours are over, they walk three or four miles, or take a tricycle-ride of several more, before dinner. The consequence is that, under the combined mental and physical strain, their digestion is impaired and their strength broken down.

Effects, somewhat similar to those of fatigue, may be produced by depressing or disturbing mental emotions, or bodily conditions. We know how readily excitement of almost any kind will destroy the appetite in some people, and depressing emotions will do it in almost every case. We not unfrequently hear of girls in whom consumption appears to have been brought on by an unfortunate love affair. If we accept the view that consumption depends upon the presence of the tubercle bacillus, we might, at first sight, think that there can be little or no connection between consumption and disappointed love; but the depressing effect of the disappointment

[1] Amongst the good old-fashioned precepts of health, not the least important is—"After dinner rest a while." I have lately seen an illustration of its utility in a patient who invariably finds albumin in his urine if he begins work (as an analytical chemist) immediately after dinner. A rest of twenty minutes, or even of twenty-five, is insufficient to prevent the occurrence of albumin, but if he rests half an hour or more the urine remains perfectly free from albumin even after a considerable amount of work.

will lessen the digestion, impair the nutrition, and render the body more likely to afford a suitable nidus for the bacillus.

Different emotions appear to affect specially, not only different organs, like the heart and intestinal canal, but different parts of the digestive apparatus. Thus, disgust affects the stomach, causing vomiting; fear is seen, in some of the lower animals, to affect the rectum, causing defæcation; compassion affects the small intestine, producing borborygmi;[1] worry and anxiety, although they act upon the stomach and lessen appetite, appear to have a very special influence upon the liver. They sometimes produce jaundice, and not unfrequently cause glycosuria; indeed, most of the cases of diabetes that one meets with in middle-aged persons appear to originate in worry or anxiety.

In treating cases of indigestion, or its consequences, due to injurious mental influences, the depressing cause must be removed if possible. If this cannot be done, change of air and scene, with exercise short of fatigue, and in the open air, are serviceable. Bromide of potassium, either alone or combined with bromide of ammonium, is very useful, both in lessening the sensibility of the nervous system to worry, and in procuring sleep, for as Shakespeare truly says:

> "Sorrow's weight doth heavier grow
> Through debt that bankrupt sleep doth sorrow owe."

It is sometimes difficult to distinguish exactly between depression that may be called purely mental, and depression due to physical causes. I have already spoken of the mental depression due to disorders of the liver, but disorders of the genital organs are also apt to give rise to mental depression, and to digestive derangements. It is difficult to say whether the genital troubles give rise to mental depression through the medium of the digestive system, or whether they disturb the digestion through the emotions; at all events, dyspepsia due to uterine and other genital disturbances is not to be overlooked. Uterine dyspepsia[2] presents the usual symptoms of nervous dyspepsia, epigastric pain, acid eructations, and sometimes vomiting after each meal. The bowels are not unfrequently much constipated.

Here, also, the first thing to do is to remedy, if possible, the condition of the uterus; next, to lessen the nervous excitability by

[1] Isaiah xvi. 11, and lxiii. 15; 1 John iii. 17.

[2] *New York Med. Rec.*, and Kisch, *Berlin. klin. Wochensch.*, No. 18, 1883.

bromides or other sedatives, and to clear out the intestines by means of purgatives.

We are sometimes too much inclined to regard digestion as a process which goes on in the intestinal canal only, and to forget how very intimately it is related to the other functions of the body. But we cannot rightly understand either the pathology of indigestion, or the action of remedies, unless we constantly bear in mind the intimate relation which exists between the alimentary canal and the rest of the body.

In the treatment of indigestion we employ several classes of drugs, one of which is known as gastric tonics. These consist chiefly of vegetable bitters. There can be no doubt whatever about their practical utility, but it is not very easy to say how they act. They increase the appetite, lessen flatulence, and tend to diminish the discomfort and languor which are apt to accompany indigestion. It is possible that part of this effect is due to their power of lessening putrefaction; but there can be little doubt that they have other actions which are not yet thoroughly understood. One of the most useful of all is nux vomica; and the great benefit derived from its use is probably due to its stimulating action on the nerve-centres by which the co-ordination of the digestive processes is rendered more perfect.

Another class of remedies is that of carminatives, which tend to disperse flatulence. Amongst the most powerful of these are ethers and volatile oils of various kinds, which probably act by increasing the movements of the stomach and intestines, and altering them in such a way as to allow the gases they contain to escape upwards or downwards. In addition to these, however, we have other remedies which, probably, act in a different way. Charcoal lessens flatulence, and is generally supposed to do so by absorbing gases in the stomach. But the power of charcoal to absorb gas is very slight when it is wet; and as it will be wetted by the fluid in the stomach after it has been swallowed, it probably has but a very slight absorbing effect on the gases there. It is much more probable that it acts merely as a mechanical stimulant, and that its use in the stomach is similar to its use as a tooth-powder in the mouth. In the healthy stomach, the layer of mucus which covers the lining membrane is very thin; but, in abnormal conditions, the mucous membrane may be covered with a thick coating of slimy mucus, which will tend to prevent absorption. The mechanical action of the charcoal will tend to remove this

coating, and at the same time the friction which it exerts on the mucous membrane will tend to increase the flow of blood through the vessels; charcoal will thus aid absorption in a double way by removing the mucus, and by increasing the circulation. If this idea regarding the action of charcoal be correct, we should expect that other inert powders would have a similar action, and this, I think, is the case. Subnitrate of bismuth, for example, is so insoluble, that it probably acts to a great extent mechanically; binoxide of manganese has a similar action; and cases of dyspepsia are reported which have been successfully treated by the administration of fine sand.

I should not venture to say, however, that preparations of bismuth act in a mechanical way only, for soluble preparations of bismuth such as the citrate have a sedative action. Moreover arsenic and bismuth belong to the same chemical group, and a small quantity of arsenic, such as one drop of Fowler's solution, given before meals seems to have a sedative action somewhat resembling that of a comparatively large dose of bismuth.

Closely allied to carminatives are stimulants, and foremost among these come alcohols and ethers. Ether, although perhaps the most powerful of all, is used less frequently alone than alcohol, but ethers mixed with alcohol, in the form of wines, are very frequently employed indeed.

The question of the employment of stimulants is one which has been greatly discussed, and which is apt to give rise to much excitement. Some would utterly abolish stimulants of every kind, while others would not only use them, but abuse them.

There is a great deal of practical truth in the definition of dirt as "matter in the wrong place." The white paint which gives brightness and cleanliness to the woodwork of a house, ceases to be clean, and becomes dirt, when it sticks to a lady's dress; and the pipeclay which the soldier uses to clean his belt dirties his uniform. So long as alcohol is in its place, it is beneficial; when it is out of place, it becomes hurtful. The difficulty here is to define the place for alcohol. Some would deny that it has any place at all, and assert that it is utterly injurious at all times, and in all places. But such assertions are valueless; they contradict the common experience of mankind, and defeat their own end by their extravagance. It is no use to deny the existence of facts, for they will continue to be facts, whether we allow them or not. What we have to do is to open our eyes to their existence, and regulate our conduct accordingly.

The question of the general use and abuse of alcohol is far too large to be entered upon here, and I have already considered it at some length in the paper which I read before the Society (p. 140), and which received its approval, as well as in others which I have written subsequently.[1] The substance of the opinion which I have always held is, that so long as a man is young and healthy, he does not require alcohol, and is better without it. I think it better in every way for people to abstain entirely from the use of alcohol until they reach the age of manhood.

I do not think it a sin to use alcohol in moderation as a luxury, provided always that it be used in moderation, not only for the individual, but for the individual at the particular time at which it is taken, for what is moderation at one time would be excess at another.

In my first lecture, I described the advantage that I had derived from a good dinner with plenty of wine. I partook freely both of the food and wine, yet I did so in what was moderation for me on that particular occasion. I was exhausted with over-work, and depressed by the effects of a cold, and neither the food nor the wine caused undue excitement at the time of dinner, nor injurious effects afterwards. Had I repeated this dinner frequently—let us say every night, twice a week, or even at longer intervals—or had I even taken it when in health, the quantity of food and wine—which was moderate for me at the particular time that I took that dinner—would have been excessive, and I should probably have suffered accordingly.

In regard to the use of alcohol in dyspepsia, I think St. Paul's advice to Timothy is very good, "Drink no longer water, but use a little wine for thy stomach's sake, and often infirmities." It is not the young and strong who require wine, but the infirm and the aged. In many cases, attention to the rules I have given in regard to rest before dinner, to mastication, and to the quantity and quality of food, will do away with the necessity for any additional stimulus to the stomach in the way of alcohol. But I think there can be no doubt that, even when all these things are attended to, there are some persons who are the better for a little wine at dinner. These are generally, as I have said, either elderly, or a little below par. When I say below par, I mean in reference to their surroundings, for some of them may

[1] The Action of Alcohol. *Contemporary Review*, Vol. XXXIII. p. 691. The Influence of Stimulants and Narcotics on Health. *The Book of Health:* Cassell & Co.

be very much above their fellow-men, physically or mentally, and yet be below par in reference to their work, or to the surroundings which put upon them such a heavy strain that they require some additional stimulus to help digestion.

It is impossible to lay down a rule for the quantity necessary, for this will vary not only with every individual, but with the individual at different times. The stimulant which is most generally useful is probably claret. With some persons sherry does well, but with others it is apt to cause acidity, a good deal of the difference being due to the kind of sherry, or so-called sherry, used. In the most severe cases of dyspepsia, brandy-and-water, or whisky-and-water, usually agree better than wines of any sort.

The methods we have considered hitherto in regard to the treatment of dyspepsia have had reference to the increase of assimilation, to the way by which we may put more fuel on the furnace of life; but the methods we have now to consider are—how are we to remove the ashes, the products of waste which would choke the fire and extinguish the life? The combustion necessary to functional activity takes place in the organs themselves, and not in the intestines, and it might be more correct to consider tissue-change, and the action of drugs upon it, before we discuss the drugs which act on the intestine; but, from another point of view, the latter is, perhaps, the more convenient.

The next class of drugs acting on the intestinal canal which we will take up is that of purgatives (p. 188).

It is evident that a regular action of the bowels is important, not only by removing the indigestible residue of food, and thus preventing fæcal accumulation, but by getting rid of some injurious products which have been formed during the process of digestion. It seems strange that one so frequently finds headache as the result of slight constipation, lasting perhaps only a few hours; whereas, in constipation lasting for weeks, it may be entirely absent. This observation seems to me to afford additional support to the hypothesis I have advanced, that headache is due, in part at least, to poisonous products formed in the intestine and absorbed from it, for Brieger noticed that it was only in the first stages of albuminous decomposition that alkaloids were formed, and afterwards these seemed to disappear. In constipation, it seems not unlikely that poisonous substances are first formed and absorbed, but that they afterwards become either decomposed or excreted by

other channels, and thus the effect which they at first produced afterwards diminishes, or disappears entirely.

We sometimes find persons in whom movement of the bowels takes place at very long intervals, and I have met with several such cases. During the time I was Casualty Physician at St. Bartholomew's, I must have seen 100,000 patients, reckoning that I saw each patient on an average three times. At first, I was accustomed to ask the question, "Are your bowels regular?" but I afterwards gave this up, because I found it was ambiguous. One day, I asked this question of a young woman, and she answered, "Yes, sir." I then asked, "How often are they open?" and she replied, "Once in three weeks, sir." Her answer to my first question was perfectly correct, for her bowels were regular, but the term regularity conveyed a different meaning to her and to me. This was an exceptional case, but I met with a number whose bowels were open only once a fortnight. In one case, they were only open once in three months, and the patient objected to take any laxative medicine whatever, as this was her normal condition. Such cases of constipation, occurring without any marked injurious result, are generally due to the fact that the patients live almost entirely upon food which leaves little or no indigestible residue, and which contains no excess of nitrogen. Most of the cases which I have seen were in women who lived chiefly upon bread, butter, with a little tea, sugar, and milk, the greater part of which would be entirely digested and absorbed, passing off as carbonic acid from the lungs, and as urea by the kidneys. In most cases, however, especially among people who are better fed, constipation of this sort is likely to be followed by very injurious results.

Where the bowels are habitually constipated, a most useful thing is to give a small aloetic pill before the last food of the day, dinner or supper, as the case may be. This slightly increases the peristaltic movements of the stomach and intestines, which would naturally be induced by the food itself; and the use of such "dinner pills" may be continued for very many years together without the least impairment to the general health.

There are fashions in purgatives, as well as in anything else; and among the fashionable purgatives at present are the saline natural waters, or the salts obtained from them. These are best given the first thing in the morning, and should be either warmed or given along with warm water. When crystallised salts are used,

such as Carlsbad salts, the quantity of water taken with them is of considerable importance. One-third to a half a tea-spoonful of the salts, in a large tumblerful of hot water, is usually sufficient to produce one loose motion immediately after breakfast; but a larger quantity of salts with a smaller quantity of water often causes abdominal disturbance, discomfort, or even pain, with several small motions at intervals throughout the day. Where evacuation of the bowels only is desired, the saline solution may be taken at a single draught; but when we wish it to act upon the liver, it should be taken in sips during dressing.

It is a matter of common observation that cases of hepatic disorder are benefited by a visit to Carlsbad, although Carlsbad salts or water have been productive of little benefit when used at home. But then they are used in very different ways at home and at the spring itself. In Carlsbad, the patient rises early in the morning, and promenades before breakfast, to the sound of music, for an hour, slowly sipping the water at intervals. I have already mentioned the powerful effect of sipping upon the heart, but it has also an effect upon the liver. It has been shown that water, slowly sipped, not only increases the amount of bile secreted, but causes it to be secreted under higher pressure, so that, if any slight obstruction should be present in the bile-ducts, it will be overcome, and the bile will flow freely into the bowel.[1]

It so happens that pharmacology, or the study of the action of drugs, takes us deeper into the secrets of the body than pure physiology or pathology; and I must now touch upon one cause of biliousness which I omitted before, namely, alteration in the condition of the bile itself. In a previous lecture, I discussed the effect on the vessels of the liver which might be produced by substances absorbed from the intestine; and I mentioned, in relation to it, the possible action of alkaloidal compounds formed in the intestine. I did not discuss the possible action of such compounds on the nature of the bile secreted, yet I believe this to be a very important condition indeed.

We observe two kinds of biliousness, or rather, perhaps, I ought to say, biliousness with two different conditions of biliary flow. In the one kind, the stools are clay-coloured, from the absence of bile; in the other, the stools are either normal, or are dark-coloured from excess of bile.

Now, certain bodies belonging to the aromatic series have a

[1] Zawilski, *Sitzungsber. d. Wiener Akad.*, 1877; *Mal. Nat. Ablg.*, Bd. iv. p. 73.

very remarkable action upon the secretion of bile. Salicylate of soda is a powerful hepatic stimulant, not only greatly increasing the quantity of bile, but rendering it much more watery than before. By thus liquefying the bile it may be useful in biliousness with increased viscosity of the bile, and also in cases where there is a tendency to the formation of gall-stones.

Other substances of the aromatic series, especially toluylendiamine, on the other hand, greatly increase the quantity of solids in the bile, and, indeed, do so to such an enormous extent that the bile becomes so thick and viscid that it will no longer flow through the biliary capillaries, and jaundice is the result. Before it has become so thick and viscid that it will not flow at all, a part of it may escape into the intestines, and give to the fæcal masses a very dark colour.

We do not yet know whether a similar action on the liver is exerted by substances—we may, perhaps, say poisons—formed during the process of digestion in the intestine. If such substances are formed, their formation might be consequent on something wrong in the food which had been taken, or on some disturbance of secretion or absorption, or might be due to foreign organisms having been taken into the intestinal canal, and having produced there abnormal decomposition. Every now and again we find a number of people living in the same house suffering from jaundice, without any cause that we can discover; but probably it is due to their having either partaken of injurious food, or having been exposed to injurious influences, especially to the ingestion of microzymes.

There can be no doubt that a blue pill and a black draught, or a few grains of calomel, have a most beneficial action, not only upon the stomach, where Dr. Beaumont was able to see the morbid changes disappear under their influence, but upon the body generally. The benefit thus obtained is usually ascribed to the cholagogue effect of the mercurial sweeping bile out from the body before time has been allowed for its reabsorption. Probably this is, to a great extent, the correct explanation, but recent researches render it not improbable that mercurials have another action, namely, an antiseptic one, in the intestinal canal, and that a good deal of the benefit derived from their use is really due to their preventing the formation of injurious products.

If the hypothesis I have advanced be correct, that the bile is sometimes rendered thick and viscid by the action of certain products of digestion upon the biliary secretion, we would naturally

expect that anything which will assist the bile to flow through the ducts into the intestine will be beneficial. Now, Lord Palmerston very truly remarked that "the outside of a horse is the best thing for the inside of a man;" and a brisk ride in the morning is better for most people than any amount of mercurials or salts. It is not merely that the person gets exercise, for a constitutional walk will not have a similar effect. It is the kind of exercise, the liver being mechanically compressed, during riding, by the diaphragm on the one hand, and the abdominal muscles on the other, so that bile is actually squeezed out of it. Where riding exercise cannot be had, rowing, or even its imitation in the gymnasium, has a somewhat similar action; and when people are unable to get exercise at all, massage over the liver will tend to lessen the accumulation of bile within the ducts.

Closely connected with cholagogues and hepatic stimulants, is another important class of drugs, namely, alteratives (p. 223).

We are only beginning to have some vague idea of how drugs act which belong to this class. Nitrohydrochloric acid is a favourite remedy, and a very useful one in biliousness. We cannot yet say precisely how it acts, but it no doubt does affect the tissue change in the liver. The reason for supposing this is that acids—nitrohydrochloric acid among others—appear again in the urine in the form of ammoniacal salts, and the ammonia with which they are combined appears to be the representative of so much nitrogenous waste, which, instead of being converted into urea in the liver, has combined with the acid, and been excreted as ammonia. This indicates that acids act upon the liver, although, as I have just said, we do not yet understand their precise mode of action. Clinically, however, we find that nitrohydrochloric acid is exceedingly useful in persons who are troubled by eructations of sulphuretted hydrogen; and it not only removes the taste of rotten eggs which is so disagreeable, but lessens the depression of spirits which frequently accompanies this form of dyspepsia. It is also useful in oxaluria and depression of spirits, even when no disagreeable eructations are present. Ammonia also has a powerful action on the liver, and chloride of ammonium has been strongly recommended in hepatic disease. It is only within the last year or so that we have learned anything definite about the action of ammonia on the liver; but it has now been shown that some ammoniacal salts increase the formation of glycogen.[1] Our knowledge of

[1] F. Röhmann, *Centralblatt f. klin. Medecin.*, 1884, No. 36.

alteratives, at present, consists only of a few isolated facts, but, before long, we may hope to have a more perfect understanding of their mode of action, and, consequently, be able to apply them more successfully in disease.

Another class of remedies which are also useful in indigestion is diuretics. Although these have no very direct action on the intestinal canal itself, they not only alter tissue-change in the body, but affect the nervous system, through which the digestive processes are co-ordinated. In some cases of gouty dyspepsia, large quantities of hot water are exceedingly useful, both by relieving dyspepsia itself and by getting rid of any urinary irritation. The diuretic action may be increased by the addition of alkaline salts; and effervescent citrate or tartrate of potash is useful both as a diuretic and as a local sedative to the stomach in neurotic or gouty gastralgia.

By the frequent use of water as a diluent, either alone or with salines, the consequences of indigestion in regard to the lungs, heart, and head, may be often averted or remedied.

Asthma occurring in gouty subjects is, perhaps, best treated by a mixture of bromide and iodide of potassium; and the addition of a little arsenic is said to increase its effect.

In cases of intermittent pulse, bromide of potassium is frequently very useful, though one of the best remedies for it is one which I believe was prescribed by the late Dr. Warburton Begbie, and consisting of two grains of powdered rhubarb, ten of subnitrate of bismuth, one and a half of nux vomica, and three of compound cinnamon-powder. This should be taken before meals; and, if there is much acidity, ten grains of bicarbonate of soda, or of magnesia, may be added to it. It may be given either in water, or, what is, perhaps, pleasanter, wrapped in a wafer and swallowed along with a little water.

Giddiness, as I have said, frequently takes the place of headache in persons of middle age suffering from biliousness, and both headache and giddiness are frequently connected with disorders of vision.

The most common causes of headache, indeed, are decayed teeth and inequalities of vision. Where the teeth are decayed, rinsing the mouth out with a lotion of bicarbonate of soda, or applying a little cucaine to the exposed pulp, will relieve the headache, and especially if combined with the use of a saline purgative. In many so-called bilious headaches, the eyes, as I have mentioned, are very

tense, and tender on pressure. Such headaches are not unfrequently relieved by the use of small doses of salicylate of soda, half a grain in an ounce of water being taken every quarter of an hour or half an hour. How this acts, it is impossible at present to say; for, though it possibly acts on the eyes themselves, its utility may also be due to its action upon the hepatic secretion (p. 74). Inequality of the visual power in the two eyes is an exceedingly common cause of headache; and I have sometimes found that a sick headache may be arrested, even after the well-known zigzags have become visible, by putting on a pair of spectacles which will equalise the eyes; or, perhaps even better, one which will compensate the weak eye, and throw the strain upon the other. Mr. Bendelack Hewetson[1] has succeeded in removing migraine by paralysing the power of accommodation by atropine.

In speaking of the disorders of digestion, I have left to the last one of the most important methods, and one which sometimes gives results little short of miraculous. This method was first introduced to the profession in America and England by Dr. Weir-Mitchell, in his book on *Fat and Blood, and How to Make Them*, but in this country it obtained little notice, until it was taken up by Dr. William Playfair. It consists essentially in passive exercises and abundant feeding. We all know how active exercise increases the appetite. Tissue-change goes on more rapidly in the organs, waste is more abundantly excreted, and more food is eagerly sought for. But there are many feeble flabby persons who cannot take exercise, or if they can, will not. Moreover, there are others who are quite willing to exercise the voluntary muscles of the limbs, but cannot exercise the involuntary muscles of their internal organs. Now, treatment by massage helps both of these. It increases the nutrition, both of the voluntary muscles and of the internal organs; and under its use patients, apparently hopelessly incurable, completely recover. Dr. Playfair has had wonderful success with cases of hysterical women; but I have been most struck with the success of the treatment in the case of a man in whom all medical treatment had proved useless. This patient, whom I first saw about two years and a half ago, in consultation with Dr. Image, of Bury St. Edmunds, was a very tall, powerfully-built man, who had been accustomed to outdoor life, and much active exercise. He had at one time suffered from asthma, but this had left him, and he

[1] Bendelack Hewetson.—The Relation between Sick Headaches and Defective Sight.—*Pamphlet.* Leeds, 1885.

became liable to attacks of pain and vomiting. I was inclined to look upon the case as one of neurotic dyspepsia, but other physicians, who had been consulted, both in this country and on the continent, regarded it as tubercular peritonitis. For two years he continued to become more and more emaciated, until at length he was reduced to the appearance of a living skeleton. Only once in

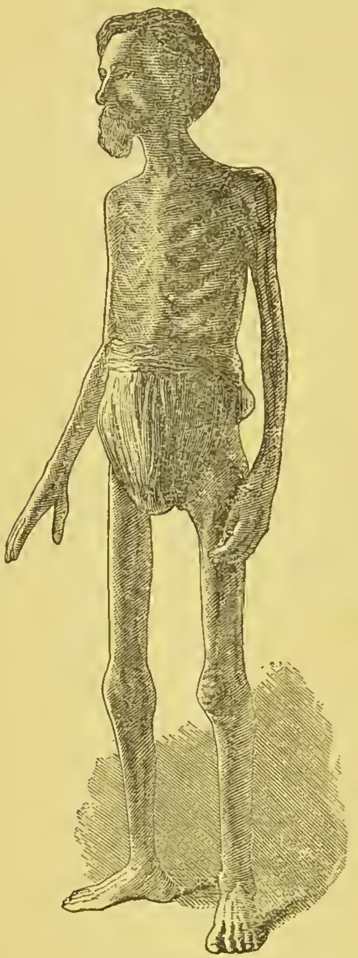

Fig. 7.—This figure, which is taken from a photograph kindly given to me by the patient for the purpose of engraving, shows his condition before Dr. Playfair begun to treat him by massage.

Fig. 8.—This figure, also taken from a photograph, shows the patient's condition after massage.

my life do I remember seeing a man so thin, and that was a person who was exhibited in a show. Dr. Playfair was at first doubtful about undertaking the case; but as Dr. Image and I were anxious that he should do so, he kindly agreed, and in the course of eight weeks our patient was a different man. Under the use of massage

and forced feeding, his muscles enlarged, until now he might perfectly well join a Highland regiment, and wear a kilt, without being ashamed. His muscles, which had almost entirely disappeared, have not only become of a normal size, but they are as hard as pieces of wood; and from being a simple skeleton, he is now a well-developed man.[1]

From the hasty sketch that I have given of the disorders of digestion, their consequences and treatment, in these lectures, it will, I think, appear that, although our knowledge of the subject is still very imperfect, a large number of observations have been accumulated, which we may hope will, before long, enable us to understand the pathology more fully, and treat these disorders more perfectly.

1 This patient wrote me a letter regarding massage, which is so important that I quote it. He says, "Will you allow me (as one who *knows*, having undergone the whole thing) to *very strongly* recommend you not to attempt *any* case without *insisting on isolation. This is of the utmost importance.* Do not attempt half measures or you will find the case will fail, and you will become disheartened. Even in my own case, though I was most anxious to get well, I feel sure it would not have succeeded had I tried it at home." Notwithstanding this advice I have tried half measures, and have found my patient's prediction verified by the failure of these attempts.

MISCELLANEOUS ESSAYS.

ON HEADACHE, NEURALGIA,

AND OTHER NERVOUS DISEASES

CONNECTED WITH THE TEETH.

(*Transactions of the Odontological Society of Great Britain*, 1880.)

THE pain of toothache localised in a decayed tooth is unfortunately so common that every sufferer diagnoses it for himself, and although it may be reckoned amongst the nervous disorders connected with the teeth, I need not say anything about it.

But toothache may be associated with other pains, or may even be replaced by them, and then the diagnosis is by no means so easy. The true cause of the pain may, indeed, remain unsuspected even by competent medical men, and their treatment may consequently be comparatively ineffectual. My attention was first drawn to the connection between decayed teeth and nervous disorders having little or no apparent relation to them by an incident which occurred a good many years ago, when I was a student. I had just heard that one of the best means of relieving toothache was to insert a pledget of cotton-wool, dipped in melted carbolic acid, into the cavity of the aching tooth, care being, of course, taken to squeeze out the superfluous acid, and to cover the pledget with some clean wool, so as to protect the tongue. I was very anxious to test the information I had received, and shortly afterwards an opportunity presented itself. A maid-servant had complained for some days of headache in the left temple of a severe neuralgic character, and associated with this was a certain amount of toothache, which was, however, less complained of than the headache. I plugged the offending tooth with cotton-wool dipped in melted carbolic acid, but was greatly disappointed to find that it produced little or no apparent benefit. In less than half-an-hour, however, the girl informed me that the pain in the

temple and the toothache were both entirely gone. Their disappearance was not due to the carbolic acid having required time to exert its action, but to its having been applied to a different point. The girl had taken it out of the cavity of the decayed molar into which I put it at first, and transferred it to another tooth, of which she had not complained, and which I had not suspected. Immediately the pain disappeared, both from the tooth and the temple.

In this case pain was felt in the tooth as well as the head, and the headache might be looked upon as simply irradiation of the pain from the tooth. But that headaches may occasionally depend upon caries of teeth in which no pain whatever is felt, is, I think, shown by what once happened in my own case. I had been suffering from migraine, the pain being limited to a spot in the left temple. There was tenderness on pressure on one spot, below and in front of, the parietal eminence. On several occasions I had noticed that the left eyeball was tender on pressure; but one day I was suffering from headache, and yet found that the eyeball was not tender. I pressed my finger all over my face in the endeavour to find a second tender spot, and at last I found one under the angle of the jaw. But the tenderness here was due to a small gland, which was hard and painful to the touch. Hardness, enlargement, and tenderness in a gland generally indicate more or less inflammation in it, and the most probable cause of such a condition is, of course, the irritation excited in the gland by foreign matter conveyed to it by the lymphatic vessels. I accordingly began to examine the mouth and teeth from which the lymphatic vessels proceeded to the gland in question. Nothing abnormal was to be noticed in the lips, cheeks, tongue, or gums, so I tested the teeth by percussion with a blunt steel point, and on the posterior aspect of the last molar on the left side of the lower jaw I found a spot which was very slightly tender. I accordingly went at once to a dentist, and learned that caries had just begun at that spot, but had not caused any cavity whatever. I had never suffered the least pain in the tooth, and but for the headache which led me to percuss the teeth systematically I should in all probability never have suspected the caries until it was far gone. The connection which was here found to exist between temporal headache and a decayed tooth is, I think, interesting, not only as showing a causal relation between the caries and the headache, but as helping to explain the pathology of migraine.

A good deal has been written on this subject, and there is a considerable diversity of opinion amongst different writers. Professor du Bois Reymond, who suffered a good deal from it, attributed it to spasm of the vessels, for he found that, during the pain, the temporal artery became tense and hard, like a piece of whip-cord, and the pupil of the eye on the affected side dilated as if the sympathetic in the neck had been irritated. Others have discarded this explanation, because they found that the vessels, instead of being firmly contracted, were distended widely, and throbbed violently, and they have attributed the pain in the head to the congestion of the vessels.

These two explanations of the pain of migraine, the one attributing it to anæmia, and the other to congestion, are apparently irreconcilable. My own case gives, however, I think, an explanation of the discrepancy. Both statements are correct, but both are incomplete, and the reason is that their authors have only observed the arteries during a part of their course, instead of tracing them backwards to the large trunks from which they sprang, and onwards to their smaller ramifications. In my own case, I have found that on some occasions the temporal artery was hard and contracted, like a piece of whip-cord, as described by du Bois Reymond. On others I found the temporal artery widely dilated and pulsating violently, and yet I could distinguish no difference between the pain I felt on these different occasions. So, not contented with noting the condition of the temporal artery only at its middle, I followed it onwards to its smaller branches, and backwards to the carotid.

Then I found that a constant vascular condition existed during the headache, notwithstanding the apparent differences in the state of the temporal artery. This constant vascular condition consisted in dilatation of the artery at its proximal, and spasmodic contraction at its distal, extremity. The carotid artery was almost invariably dilated and throbbing. Sometimes the dilatation would extend as far as the trunk of the temporal artery, but sometimes the temporal was contracted. Even when the temporal artery was dilated, if I only followed it to its smaller ramifications they were found to be firmly contracted and cord-like. If one may reason from this single instance, connecting as it does the examples of vascular dilatation and contraction given by other authors, we may say that the pain of migraine depends neither on contraction nor dilatation of the vessels *per se*, but upon dilatation of one part of

the vessel with spasmodic contraction of another, or, if we might so term it, upon a state of colic in the vessels themselves. This irregular contraction of the vessel is almost certainly due to disordered vaso-motor innervation. The cause of this disorder is to be sought in the sympathetic system, and the observation of du Bois Reymond regarding the condition of the iris may lead us to connect it with the cervical ganglia. From these ganglia, vaso-motor fibres proceed along the carotid and its branches, and if we regard disorder of these ganglia as the cause of migraine we are at once in a position to explain some of the symptoms which occasionally accompany it. Thus, I have observed that sometimes the pain in the temple would suddenly cease, and be replaced by pain in the occipital region. Sometimes, also, we have affections of the sight, such as general dimness of vision, diplopia, and spectra—coloured or uncoloured. The transference of pain from the temple to the occipital region is probably caused by transference of the spasmodic contraction from the temporal to the occipital artery, and the disorders of the sense of sight we may reasonably regard as caused by alterations in the intercranial branches of the carotid, similar to those which we can detect by the finger in its temporal branch. The disturbance in the sympathetic system, which I regard as the cause of migraine, may not always have its origin in the teeth; it may, and very probably does, sometimes originate in the eyes, but in the instance which I have already noted as occurring in my own case, the irritation started from the lymphatic gland, on or about which branches of the sympathetic probably ramified. The tooth itself, although the real cause of the sympathetic irritation, did not produce it directly, but indirectly. From the root of the tooth the lymphatics conveyed irritating matter to the gland, and the irritation here excited acted in its turn as a disturber of the sympathetic nerves which furnish the vaso-motor supply to the carotid and its branches.

The connection between dental caries and neuralgia was first noticed by Neucourt,[1] and he gives rules for diagnosing a causal relation between caries and neuralgia. When the pain, which is at first widespread, gets localised, in the course of a few days, in the dental region, and is succeeded by redness, swelling, and tenderness on pressure of the gums, the neuralgia is almost certainly of dental origin. In these cases the patients are restless, and the pain is more or less constant, with no distinct

[1] F. Neucourt, *Arch. Gén.*, Juin, 1849.

intermissions; the pulse is more frequent and hard, and there is not unfrequently sweating. If the pain is followed by a gum-boil, the tooth, he thinks, is certainly decayed, although it should present no appearance of caries, and this he considers to be also the case if the tooth appears longer than the others and is painful on percussion. Tenderness on percussion is considered by Richter[1] to be the most certain sign. The diagnosis may be assisted by noticing whether the neuralgia when disappearing lingers longest in one of the teeth.

The exact pathology of neuralgia has not yet been settled, but Valleix, one of the great authorities on the subject, gave as its distinctive points the presence of spots which were tender on pressure, and the effect of pressure in increasing the pain. These spots have been noticed by Neucourt[2] in neuralgia depending upon dental irritation, and he has also observed the absence of increased pain on pressure in true neuralgia, so that no distinction can be drawn between neuralgia due to dental irritation and neuralgia depending upon other causes.

Although the most frequent seat of pain due to carious teeth is the temporal region, yet, as one would expect, we find it also in parts of the neck. A few weeks ago I was consulted by a lady regarding her throat. She had pain opposite the upper part of the thyroid cartilage on the right side, and thought that she had inflammation at that point. Laryngoscopic examination showed the larynx to be perfectly healthy, but I found one of the molars on the same side as the painful spot to be extensively diseased. The pain from which she suffered, I have little doubt, was caused by the decayed tooth; but, as she refused to have it extracted or stopped, I could not absolutely verify my diagnosis. I put her upon a course of tonics and the pain almost completely disappeared.

This would be said by some to prove my diagnosis to be wrong; for if the pain depended on the presence of a carious tooth, how could it disappear while the tooth remained unattended to? But we must always remember that the actions which take place in the animal body are not so simple as those which occur in the test-tube of a chemist. Yet even in the test-tube we require more than one reagent to produce a reaction; and if one of the substances or conditions necessary for the reaction be absent, it

[1] Richter, Schmidt's *Jahrbücher*, 1850-4, xv. p. 46.

[2] F. Neucourt, *Arch. Gén.*, Oct. to Dec., 1853; Jan., 1854.

does not occur, even though other conditions be present. In the same way we know that a decayed tooth does not always cause toothache, and that toothache, when present, may frequently be removed by the use of a saline purgative. The tooth still remains as a source of irritation, but the state of the nervous system has been so altered by the purgative, that pain is no longer produced by the irritation. In the same way we may not unfrequently relieve the neuralgia originating from decayed teeth by a judicious course of aperients and tonics. This is so far advantageous to the patient, as it relieves him from pain; but it is, on the other hand, disadvantageous, inasmuch as it causes the medical man to overlook the real source of the evil, and allows the dental caries to proceed instead of having it arrested by suitable stopping. In the case I have just mentioned, the pain in the larynx, which I attributed to the decayed tooth, did not lead to any change in the nutrition or functions of the larynx. Pointis,[1] however, records a case in which, after severe toothache, the patient suddenly lost his voice, and the aphonia was followed by anorexia, cough, wasting, and feverishness, which led to the belief that he was suffering from laryngeal phthisis. But the lungs were sound, and there was no tenderness over the larynx. There was slight inflammation of the pharynx, all the molars on the left under-jaw were decayed, and the gums and periosteum around them were swelled. The teeth were removed, the gums cauterised, and gargles employed. On the very day the teeth were extracted, the suffocative spasms which had troubled the patient abated, and on the following days the other symptoms quickly disappeared.

The irritation caused to the larynx by the process of dentition is well recognised, and has led to the employment of the term teething-cough. The existence of a real causal connection between cough and teething has been doubted; but there are cases on record which seem to show that this really does exist. One very marked instance of this sort has been recorded by Paasch.[2] A child, four months old, had a paroxysmal laryngeal cough, during which it was nearly suffocated, opening its mouth and throwing the head back. Narcotics were of no use. The gum of the lower jaw was swelled, and vesicular swellings appeared at the part of the gums corresponding to the middle incisors. These increased in size and became dark, livid, translucent, and fluctuating.

[1] Pointis, *Journ. des Conn. Méd. Prat.*, Sept., 1846.

[2] Paasch, *Journ. of Kinderkr.*, 3, 4, 1856.

During their growth, the cough increased; but when the right incisor came through the gum, and one vesicular swelling broke, the cough ceased. After twenty-four hours it again began, though less violent than before. After some days the second incisor came through, the second vesicle burst, the cough at once began to disappear, and at the end of two days had entirely and for ever gone.

From the close connection that exists between the throat and the ear we would expect deafness to be not unfrequently the consequence of dental irritation. It seems, however, not to be very frequent, although it does exist, as shown by the following case recorded by Koecker.[1] A man, aged forty-eight, suffered from suddenly-increasing deafness; but after his teeth, which were carious, and had caused suppuration of the gums, were extracted, he completely regained his hearing.

The eye is much more frequently affected than the ear, and blindness is by no means an uncommon result of dental decay. Mr. Jonathan Hutchinson has recorded some cases of this, and he regards the blindness as reflex, and analogous in its causation to essential paralysis of children. The sight is suddenly lost, but there are no cerebral symptoms. The optic nerve is sometimes atrophied, but sometimes not. The blindness is generally preceded for a long time by facial neuralgia, associated with toothache. A more striking case than any of Mr. Hutchinson's is recorded by Dr. De Witt.[2] A perfectly healthy man, aged thirty-one, suddenly noticed, in attempting to fire off a gun, that his right eye was completely blind. He had neither pain nor subjective appearances of light in the eye. He was able to distinguish light from darkness with it, but nothing more. No cause for this blindness could be discovered until twelve years afterwards, when it was found that the patient had several teeth stopped two months before his blindness. For a long time afterwards he suffered from pain and tenderness in the first molar of the right side. The gums swelled and ulcerated, and frequent abscesses formed, which he opened with his knife. The stopping was at length removed from the tooth, and this at once relieved the irritation of the gums, and increased the power of sight. In three weeks, however, when the sight had already become considerably better, the gums again ulcerated, and the sight became immediately worse. The decayed tooth was then extracted, and the sight became permanently

[1] Koecker, *Med. Chir. Rev.*, Jan., 1843.

[2] De Witt, *American Journ.*, *N.S.*, cx., p. 382, April, 1868.

improved, although it never became quite so good as that of the other eye.

The connection between the teeth and the sight has been long popularly recognised in the name of "eye-teeth" given to the canines, and this seems to depend on no popular superstition, but on a real scientific fact. It is believed by many that the extraction or decay of a canine leads to loss of sight, or inflammation in the corresponding eye, and the physiological experiments of Magendie and Schiff substantiate this belief.

Magendie divided the inferior maxillary branch of the fifth, and Schiff divided the lingual and inferior dental branches without injury to the ophthalmic branches.[1] The dimness of vision pro-

[1] In his work on Physiology and Pathology, Schiff says: "Magendie, in 1838, showed, in one of his lectures, a small dog, in which he had divided the inferior maxillary branch of the fifth nerve some time previously. Hitherto," he said, "only those parts were affected to which the branch was distributed; but in the present instance disturbances of the visual power had appeared some days ago. There was no such opacity as that which follows section of the fifth pair of nerves in the skull, but only a little cloudiness between the lamellæ of the cornea. Their transparency was not completely lost, but there was a condition intermediate between complete transparency and commencing opacity. It appeared to him, also, that the sensibility of the eyes was somewhat altered. When engaged in another research, I have divided, in a number of dogs, sometimes the lingual branch alone, and sometimes the inferior dental branch, high up at the point where it branches off from the inferior maxillary nerve. Since here the nerve was exposed and divided outside the skull, neither injury nor compression of the ophthalmic branch is to be thought of. No doubt, by my method of operation, traction was exerted on the inferior maxillary branch which was seized by the forceps; but the traction was exerted rather against the periphery than the centre, the dental branch being partly drawn out of its canal in the lower jaw. In most of the animals operated on, nothing remarkable was to be seen, but in about a third of them (four out of eleven) an affection of the corresponding eye appeared from four to eight days after the operation, without my being able to discover any reason for this peculiarity in the way in which the operation had been performed. The conjunctiva became injected, and the injection went on increasing for two or three days, but never became so great as it does after division of the trigeminus. The eye was moist, and covered with a thin layer of the same mucus which is secreted so abundantly after paralysis of the ophthalmic nerve. The cornea did not become opaque, but exhibited a partial greyish dimness, which extended from the centre in irregular form, to a varying extent, sometimes towards the upper and sometimes towards the under edge. The eye exhibited no perceptible diminution of sensibility; the pupil remained perfectly mobile, and exhibited all the usual synergetic contractions on movement of the eyeball.

"The dimness of the cornea increased for a short time, and in about twelve days from its commencement it disappeared completely, leaving the eye perfectly normal. During all this time the animals were perfectly lively, and their general condition underwent no change.

"On what do these peculiar phenomena depend? Certainly on the weakening of the vaso-motor nerves in the district supplied by the ophthalmic nerve. But, as this nerve

duced by these experiments is referred by Schiff to disturbance of the vaso-motor supply to the eye, consequent upon a partial paralysis of the ophthalmic branch of the fifth; but as this nerve itself was not injured in the experiment, it is evident that the vascular alterations are of reflex origin, the irritation having been conveyed from the site of the wound to the nerve centres, and having there exerted such an influence upon them as to induce vascular changes in the eye.

The eyelid may also be affected reflexly from the teeth. Sometimes dental irritation may cause motor spasm, and at other times paralysis. A year or two ago I had the stump of a bicuspid tooth extracted from the right upper jaw. Almost immediately after the extraction I noticed a constant spasmodic twitching in the right eyelid, which I was utterly unable to restrain. This lasted all the time the wound in the gum caused by the extraction of the stump was

itself was not touched, some pathological process must needs have been propagated from the wound of the third branch towards the centre, and there have extended over the original district of that branch. This very general conclusion appears to me well-grounded; for I cannot believe that in these cases the hyperæmia of the eye on the side operated upon was due to chance, for this affection of the eye never occurred in any one of the numerous dogs which I kept under observation after other operations. The ophthalmic nerve here was not paralysed, for the phenomena were not very intense, and the sensitiveness of the eye had not suffered.

"The explanation of this was all the more obscure, as I had previously convinced myself that no pathological changes could be discovered by the microscope in the central end of the divided nerve. Besides, I had performed the same operation on the third branch of the trigeminus in a great number of cats, and no affection of the eye occurred in them. I therefore utilised the opportunity of studying more carefully the anatomical changes which are associated with this transitory condition, which was afforded me in 1852 by two young dogs, which exhibited this dimness of the cornea after resection of the inferior dental nerve. The dogs were killed from six to ten days after resection of the nerve. The swelling and alteration of the divided end of the nerve were no greater than is usually the case after such resections. There was, as usual, an exudation of nucleated globules between the nerve-bundles in the neighbourhood of the wound. Neither the inferior maxillary, higher up, nor the ophthalmic, exhibited anything abnormal under the microscope. A slight redness of the coverings of the nerve immediately below the exit of the third branch from the cranium could only be regarded as accidental, and perhaps due to the traction on the nerve trunk during the operation—and all the more as this redness was greater in the animal killed on the sixth day after the resection, and in which the dimness of the eye was less than in the dog killed on the tenth day. In both animals, it appeared to me that within the cranium the arachnoid covering the pons on the operated side, as well as the pons itself at the root of the fifth nerve, were more injected than on the corresponding parts of the other side. But any one who knows how inconstant and variable is the amount of blood inside the cranium will excuse me when I state this with considerable reserve. Both animals were killed with strychnine."—Schiff, *Untersuchungen zur Physiologie des Nervensystems mit Berücksichtigung der Pathologie.* Frankfort, 1855, p. 112.

open, but it ceased as soon as the gum had healed, and has never since returned. A case is recorded by Gaine[1] in which a carious tooth of the upper jaw had caused an abscess in the antrum. The right upper lid was paralysed, the pupil dilated, and there was no reaction. The optic nerve was pale, and the eye blind. On extraction of the tooth and puncture of the antrum the paralysis of the lid disappeared, although the eye did not regain sight.

Spasmodic contraction of the masseters is another consequence of dental irritation. A few weeks ago a gentleman, over forty years of age, called upon me and told me that he was much concerned about a spasmodic affection of the jaw from which he was suffering. He was, in fact, afraid of lock-jaw. He felt obliged to keep his mouth open, because it seemed to him that if he once shut it he would not be able to open it again. I did not recollect having read any description of this affection, but it seemed evident that it must depend either upon congestion of the cerebral centre for the movement of the jaw, which Ferrier locates at the lower end of the fissure of Rolando, or on reflex irritation from the mouth itself. The latter seemed to be much the more probable, and on looking into his mouth I saw that the teeth did not seem to be altogether in good order. I accordingly requested him to see a dentist, and, on inspection, the source of irritation was discovered to be a wisdom-tooth, which was just making its way through the gum, but in a somewhat oblique direction, so that its crown was pressed against the molar in front of it. On looking up the literature of the subject, I discovered that this affection was pretty fully described by Germain,[2] who recognised two causes of this form of trismus. The first is when the back molar is decayed, and a gumboil forms at its base, and the other is when the attachment of the masseter extends in front of the angle of the lower jaw, and the wisdom-tooth, in appearing, must break through its muscular and fibrous attachment. Colin[3] states that every year he sees at least one perfectly healthy individual become suddenly affected with spasmodic contraction of the masseters. There is no fever, but the contraction is so strong that only fluid nourishment can be taken. The contraction can be felt by running the finger over the masseter muscle. It gradually disappears in about eight or fourteen days. Little treatment is required except attention to the bowels,

[1] Gaine, *Brit. Med. Journ.*, Dec. 30th, 1865.
[2] Germain, *Gaz. Hebd.*, 1863, x. 7.
[3] Colin, *Études Cliniques de Médecine Militaire.*

and possibly, if the contraction be very severe, an injection of atropia into the muscular substance itself might be of service.

We have already noticed paralysis of the eyelid as a consequence of dental irritation, and we have also discussed the pathology of temporal and occipital headache in relation to caries of the teeth. Sometimes, however, paralysis occurs of a much more extensive character, in consequence of dental irritation, especially in children. Teething is recognised by Romberg and Henoch as a frequent cause of paralysis appearing in children without any apparent cause.[1] According to Fliess,[2] paralysis of this sort occurs more commonly during the period of the second dentition, whereas convulsions generally occur during the first. Its onset is sudden. The child is apparently in good health, but at night it sleeps restlessly, and is a little feverish. Next morning the arm, or more rarely the leg, is paralysed. The arm drops; it is warm but swollen, and of a reddish-blue colour. It is quite immovable, but the child suffers little or no pain. Not unfrequently paralysis is preceded by choreic movements. Sometimes recovery is rapid, but at other times the limb atrophies, and the paralysis may become associated with symptoms indicating more extensive disturbance of the spinal cord and brain, such as difficulty of breathing, asthma, palpitation, distortion of the face, and squint, ending in coma and death.

It is only in very rare instances that we are able to gain any insight into the pathological anatomy of such cases, because they rarely prove fatal, and even when they do so the secondary changes are generally so considerable as to leave one in doubt as to the exact mode of commencement. This renders all the more valuable the case recorded by Fliess, in which a boy five years old, and apparently quite healthy, found his left arm completely paralysed on awaking one morning after a restless night. The arm was red, but the boy suffered no pain, and played about without paying much attention to the arm. The same day he fell from a waggon upon his head, and died in a few hours. Apart from the fracture of the skull, which caused his death, the anatomical appearances which were found were congestion of the spinal cord, and great reddening and congestion of the meninges, near the point of origin of the brachial nerves, where the veins were also much fuller than on the corresponding right side. There was no organic change perceptible, either in the spinal cord or in the brachial nerves. On

[1] *Klinische Wahrnehmungen und Beobachtungen.*

[2] Fliess, *Journ. der Kinderkr.*, 1849, July and August.

the other hand, the turgescence of the veins extended from the shoulder and neck up to the face, and was very striking in the sub-maxillary region.

This vascular congestion seems to point to vaso-motor disturbance of a somewhat similar kind to that which we have already noticed in connection with occipital headache, or with migraine accompanied by subjective appearances of either form or colour.

Dental irritation may give rise to choreic movements, occurring as the prodromata of paralysis or to chorea alone. This irritation may depend, according to Levick,[1] either upon the second dentition, or upon dental caries, and the causal connection between the irritation and chorea is shown by the fact of its disappearing when the tooth pierces the gum, or when the carious teeth are extracted.

According to Russell Reynolds,[2] the second dentition is also a cause of epilepsy, and he has observed that those who are affected by it have often suffered from convulsions during the first dentition. A case is recorded by Albrecht[3] of a boy, aged twelve, who suffered daily for twelve months from general convulsions, which began in the temporal region and extended to the external auditory meatus. There was no decay in this instance, but the teeth were large, and the last molar on the right side had its crown jammed into the ascending ramus of the jaw. As soon as it was extracted the pain ceased, and the convulsions did not return. Another case is given by Mr. Castle[4] of a young man, aged nineteen, who had complained for four years of headache and pain in the eyes, stiff-neck, swelling, and numbness of the right arm. For the latter two years he suffered from general convulsions, which came on every two or three days, ending with vomiting, and often succeeded by partial deafness. All treatment was useless, and setons and blisters to the neck did no good. Nearly all the teeth were decayed; nine were extracted, and almost all of them had matter at their roots. A gargle was given, with five grains of iodide of mercury twice a day, and a purgative twice a week. After the extraction of the teeth the fits entirely disappeared.

In a case recorded by Lederer,[4] the second left upper incisor was replaced in a young girl by an artificial tooth. Shortly afterwards

[1] Levick, *Amer. Journ. of Med. Sciences*, Jan., 1862, p. 40.
[2] Russell Reynolds's *Lancet*, July, 1848.
[3] Albrecht, Casper's *Wochenschr.*, 1837. [4] Castle, *Lancet*, Jan., 1848.
[5] Lederer, *Wein. Med. Presse*, vii. 24, 1866.

she became ill, vomited everything, and suffered from convulsions. No remedy succeeded until the tooth was removed and shortened. Immediately all the symptoms from which she had suffered disappeared.

Affections of the intestinal tract depending on dental irritation are of very considerable importance indeed.

In adults many a case of dyspepsia is due to defective teeth. It may be partly caused by reflex affection of the secretory and motor nerves of the stomach and intestines, but partly also, without doubt, by the imperfect mastication of the food, which is swallowed without being broken up on account of the pain or inconvenience which the act of mastication causes. In this way two evils are occasioned. First of all, the shortened sojourn of the food in the mouth allows no time for the secretion of saliva. From want of this the starchy constituents of the food are imperfectly digested; and, moreover, deficiency of saliva also lessens the normal stimulus to the secretion of the gastric juice; for alkaline fluids, like saliva, stimulate the secretion from the stomach, and deficiency of saliva is accordingly followed by a deficiency of the gastric juice. But, secondly, imperfect mastication has a mechanical action in preventing perfect digestion, for the food, being swallowed in lumps, is not permeated by the digestive fluids, and thus cannot be dissolved in anything like the same period of time that it would otherwise be.

The diarrhœa which comes on in children during dentition is well known, and is probably of a reflex character. It is probably produced through the gastric and intestinal branches of the vagus, and other branches of this nerve may be affected reflexly from the teeth.

The close connection between the roots of the fifth nerve, and those of the vagus, can be demonstrated anatomically, and it is probably in consequence of this that irritation of the fifth is able to exert such a powerful influence upon the circulation. Some time ago, in a paper which I published in the *British Medical Journal*,[1] I mentioned that one cause of death during the extraction of teeth under chloroform was probably the stoppage of the heart's action through the inhibitory fibres of the vagus, associated with a reflex depression of tone in the blood-vessels. The reason why the extraction of a tooth in a person who is not under the influence of an anæsthetic, is followed by no ill effects, is probably this:

[1] *Brit. Med. Journ.*, Dec. 4th, 1875.

that in him the irritation of the fifth nerve produces two distinct actions which counterbalance each other. It may cause reflex stoppage of the heart through the vagus; but at the same time it causes reflex contraction of the vessels through the vaso-motor centre. This contraction of the vessels maintains the pressure in the arterial system during the stoppage of the heart, and thus no harm whatever is done. When an anæsthetic is used, however, one of these pieces of nervous mechanism may be paralysed by it, while the other is not, and thus the extraction of the tooth may stop the heart without causing contraction of the vessels. The blood-pressure will then sink very rapidly in the arterial system, and fatal syncope may be produced. If, however, the anæsthetic be pushed to a greater extent, so that both parts of the nervous mechanism just mentioned are paralysed, the vessels are not contracted, but neither is the heart stopped. The operation is therefore comparatively free from danger when no anæsthetic has been given, or when the anæsthesia is perfectly complete, the period of danger being that of imperfect anæsthesia.

We have now seen how affections of sensation, of motion, and of nutrition may all be dependent upon dental irritation, but even the cerebral faculties themselves may also suffer from a similar cause. One or two very interesting cases of this sort are recorded by Dr. Savage in the *Practitioner* for June, 1876. The first of these was that of a farmer, aged twenty-two, with a strong family tendency to insanity. In May, 1875, he suddenly took to riding madly about the country without his coat and waistcoat. From May until November he was exceedingly noisy, destructive, untidy, almost constantly excited, and if for a day or two he was exhausted, he was sullen and more dangerous. In the middle of November he complained of very severe toothache that caused him to be sleepless. He bore this for two or three days, after which the stump was removed. There was suppuration at the root of the fang. From the time that the stump was extracted the patient steadily improved, and by the middle of December was quite well. Another case was that of a woman, aged thirty-four, who had a brother insane, and had herself been intemperate. She was admitted in September, 1875, suffering from acute mania. She was noisy, violent, and obscene. She continued to be so until January 20th, 1876, when she complained of great pain, with swelling, and redness of her right lower maxilla. She had some bad teeth, but did not complain of toothache. The pain and

swelling increased, and at the same time she became quiet and reasonable. She said she could not remember much of her state of excitement. The swelling of her face subsided, and she remained quite well. This case, however, was not so convincing as the first one recorded, because here there was a second possible cause of recovery, as she was pregnant, and said she felt quickening about ten days before her recovery. The recovery, however, was coincident with the pain and swelling of the face, and seemed, rather than the quickening, to be the cause of recovery.

ON THE PATHOLOGY AND TREATMENT OF SOME FORMS OF HEADACHE.

(*St. Bartholomew's Hospital Reports*, VOL. XIX.)

Of all the kinds of pain which afflict humanity, or at least civilised humanity, there is perhaps none which causes a greater amount of misery than headache. Although the pain of it may not unfrequently be slight, yet the number of people affected by it, the frequency of its recurrence, and the intensity which it sometimes attains, raises the total amount of pain produced by it to such an extent, that the means of relieving or curing it becomes a most important therapeutical question. We all know that the part of the nervous system by which sensations either of pleasure or pain are perceived is in the brain; for if communication between the head and the body or its parts is destroyed by section of a nerve or of the spinal cord, the individual is totally unconscious of any impressions made upon the periphery. The exact seat of sensation has been further localised by my friend Dr. Ferrier, who has ascertained that the destruction of the hippocampal convolutions on the one side of the brain produces anæsthesia of the opposite side of the body, so that neither pinching nor touching with a hot iron gives rise to any evidence of sensation. We may therefore look upon the hippocampal convolution as the seat of sensation, at least for the surface of the body, whatever may be the seat of sensation for internal organs.

In a condition of health the sensory centres in the brain perceive no pain unless some injury is happening to a part of the body, and pain is thus a useful monitor, warning the individual to stop the mischief which is occurring before it be too late. In certain unhealthy conditions of the brain, however, the sensory centres in the brain may be so affected that pain is felt although no injurious

process whatever is occurring in any part of the body. Such a condition is probably the explanation of what we find in hysteria, when such intense pain may be felt in a joint, for example, as to induce the patient to insist upon the amputation of a perfectly healthy limb. In such a case as this the disease appears to be due entirely to alterations in the sensory centres in the brain, while the whole body appears to be healthy. I say *appears*, because, even in such cases, it is possible, and indeed probable, that some morbid condition may be present which has escaped our notice, because there may have been little or nothing to direct our attention to it as the cause of the disease. But the sensory centres in the brain are securely lodged within the skull, and are not likely to undergo any morbid change unless it is started either by alterations in the quality or quantity of the blood circulating through them, or by impressions conveyed to them by afferent nerves. We find, as a rule, in the healthy body, that irritation of any part is felt in the place to which the irritant is applied, so that attention is consequently at once directed to it, and an effort made for its removal; but this is not always the case, for even in the healthy body we find it is sometimes difficult to localise an impression. Perhaps no better instance of this can be given than the bite of a flea, which is sometimes felt two or three inches from the real seat of irritation. In abnormal conditions this reference of irritation to a spot where no irritant is present may be greatly increased. In the case of hysterical pain in the knee-joint, to which I have already referred, the source of irritation is not in the knee, but is probably, to a considerable extent at least, in the sexual organs, from which afferent impulses proceed to the brain, and there induce morbid changes which are probably similar in kind to those which would have been caused by acute irritation in the knee-joint; pain is thus felt by the individual, and referred to the knee although the joint itself is perhaps healthy. When such a pain as this is felt by persons presenting certain general characteristics, we call it hysterical, but in its essentials it is simply neuralgic. The term neuralgia is a very convenient cloak for our ignorance, and we apply it as a rule to all acute pains for which we can find no apparent cause. A good deal of discussion has arisen regarding the nature of neuralgia, and several writers hold that neuralgic pain is of central origin. According to this view, we may look upon hysterical pain in the knee-joint as a most marked and typical neuralgic affection. This view is probably the

true one so far as it goes, but it is imperfect, and will, I think, mislead us if we do not try to find out in all cases the peripheral origin of the central changes, for in minor neuralgias, as in the case of hysterical knee-joint, the changes in the brain are probably started by some irritation of sensory peripheral nerves. Thus pain in the temple is very frequently due to the irritation of a decayed tooth. Sometimes a pain may be felt in the tooth as well as in the temple, just as in the ordinary experiment on the so-called funny bone, pain or tingling may be felt at the elbow where the ulnar nerve is twitched as well as in the fingers to which its terminal branches are distributed. Sometimes, however, this is not the case, and the pain is felt in the temple without any in the teeth. My attention was first directed to the relation between pain in the temple and decayed teeth many years ago. A servant of my brother's was suffering from toothache, but complained still more of intense pain in the temple. I did not know what to do for the pain in the temple, but thought the toothache might be relieved by applying solid carbolic acid on a pledget of cotton wool. I accordingly introduced this into a large cavity in one molar. To my great disappointment it gave no relief whatever. In the course of a very few minutes, however, her fellow-servants came running to tell me that cook was now quite free from pain; that she had taken the cotton wool out of the tooth into which I had put it and placed it in another decayed tooth, and at once the pain vanished both from the tooth and the temple. In this case the irritation of a decayed tooth had produced a two-fold pain—a pain felt in the tooth itself, and also one felt in the temple; but sometimes a decayed tooth will cause headache when no pain is felt in the tooth itself. I was first led to observe this by watching my own case. One day I was suffering from severe megrim, the pain being limited to the left temple; there was tenderness on pressure over the spot. On many other occasions I had noticed that the eyeball was tender at the same time, but on that occasion there was no tenderness of the eyeball. Passing my finger over the side of the head and face in the endeavour to find a second tender spot, I at last came upon one under the angle of the jaw. The tenderness here was due to a small gland, which was hard and painful to the touch. The occurrence of an enlarged gland at once led me to seek for the source of irritation in a district from which it received the lymphatic vessels, and I accordingly examined the mucous membrane of the mouth and tongue,

but without seeing anything abnormal. I then took a steel point, with which I probed and percussed all my teeth in succession. Every one was sound excepting the last molar on the same side as the headache, and on the posterior aspect of this there was a point, tender on pressure, although no cavity could be found. I went to a dentist as soon as possible afterwards, and he informed me that caries was just beginning at the spot which I had thus discovered. Some time ago a clergyman of my own acquaintance began to suffer from headache so intense as completely to incapacitate him. After taking various medicines in vain, he went for a Continental tour, but came back little benefited, and as soon as he resumed work the headache was as bad as ever. Shortly after his return I saw him, and remembering my own experience, I suspected his teeth. On looking into his mouth, however, I could see nothing; all his teeth seemed to be perfect. I then took a steel bodkin and probed and percussed each tooth in succession. At last I came to one which was tender. I advised him to see a dentist about it. This he accordingly did, and the tooth was found to be carious. It was at once properly stopped and the headaches disappeared. So frequently are headaches dependent upon decayed teeth, that in all cases of headache the first thing I do is carefully to examine the teeth. Not unfrequently when I have pointed to a decayed molar as the origin of the headache, the patient has said, "But I have no pain in the tooth;" and to this I usually answer, "It is quite natural. You get the toothache in another part of your head."

The question now arises, what is the cause of the pain felt in some other part of the head instead of the seat of irritation, but originating in some local irritation like that of a decayed tooth? Is it only due to changes in the centre for sensation in the brain, or to alterations in the periphery, or to both? I am inclined to believe that while it may sometimes be due to changes in the centre for sensation in the brain only, as in the case of hysterical pains, yet sometimes functional peripheral changes either accompany these central changes, or may of themselves give rise to the pain. In this latter case the peripheral alterations are probably produced through the medium of the sympathetic system. Thus I have noticed that the scalp, over the place where the pain is felt in headache depending on a decayed tooth, becomes tender on pressure while the pain lasts. This tenderness, however, is very transitory, and I have sometimes felt the headache and accompany-

ing tenderness disappear from one part of the head and appear in another with great rapidity. The disappearance of the tenderness along with, or very shortly after, that of the pain, shows that there can be no structural alteration of any importance in the tender part. There may, however, be very important functional changes in blood-vessels of the painful part, and I think that headache is very frequently due to those changes; that, in fact, what we may regard as a kind of colic in the vessels occurs in the part, and this gives rise to the actual pain.

The mechanism of the headache here is that the irritation in a tooth, for example, acting through the vaso-motor nerves, causes vascular spasm, and this vascular spasm causes the pain of headache.

Fig. 9.—A very diagramatic representation of the connection between the branches of the fifth nerve and the sympathetic system, intended to indicate the nervous channels through which irritation of the fifth nerve may affect the vessels of the head.

In cases of headache and toothache combined, the headache may be simply due to changes in the centre for sensation in the brain, or these may be accompanied by spasm in the vessels of the head.

In cases of headache depending upon a decayed tooth, where no toothache is felt, it is not improbable that the irritation in the tooth does not give rise directly to the sensation of pain in the head, but does so by acting through the sympathetic system on the vessels so as to cause the spasm which leads to the sensation of pain. If this be so, we ought to be able to alleviate headache, not only by treating the tooth which is the original source of the evil, but also by such measures as will relieve the spasm of the vessels themselves, and this, I think, is shown to be the case in practice.

A great deal of discussion has taken place regarding the condition of the vessels in megrim. Du Bois-Reymond, who suffered much from it himself, attributed the pain to spasmodic contraction of the vessels, for he found that while the pain lasted his temporal artery on the same side became tense and hard like a bit of whipcord, and the pupil of the corresponding eye dilated, as if the sympathetic in the neck had been irritated. Others again have held, also on the ground of personal experience, that the arteries, instead of being contracted, were widely dilated. The reason of this discrepancy is simply, I think, that these observers have not examined the arteries throughout their length. In my own case I have sometimes found that during an attack of megrim the temporal artery on the affected side was hard like a bit of whipcord as described by Du Bois-Reymond, but that at other times, when no difference between the amount and kind of pain could be detected, it was widely dilated and pulsating violently. But on those occasions, if I traced it along its course, I found that while the trunk of the artery was dilated at the temples, its smaller branches as they passed on to the forehead were hard and contracted, and felt almost like pieces of wire under the skin. The carotid artery was also widely dilated and pulsating violently, as well as the temporal. The condition here then was a disturbance in the proper relation of the calibre of different parts of the same artery. The proximal end was abnormally dilated; the peripheral end was abnormally contracted. The same condition is present in those cases where the trunk of the temporal artery is contracted, for if the finger be carried backwards, the trunk of the carotid is felt to be dilated.

The only difference, then, between those cases of megrim in which the temporal artery is dilated and those in which it is felt to be contracted is a difference in the point of the artery at which the contraction takes place. The consequence of this disturbance in the relationship between different parts of the artery is that the blood, instead of being gradually regulated in its onward flow by the gentle action of a long artery, is suddenly checked by a local contraction, and the successive impulses produced by the jets of blood sent from the heart along the dilated arteries hammering upon this contracted point give rise to great pain. This pain can be at once relieved by compressing the carotid, so as to arrest the flow of blood through it; but unfortunately a feeling of undefinable distress is usually produced by this procedure, so that one can

generally keep it up only for a few moments. It may sometimes be relieved for several minutes by gently pressing on the carotid, so as simply to diminish its flow without entirely arresting the circulation in it.

Heat and cold are two of the remedies used to lessen headache; sometimes one is useful, sometimes the other; and so far as I know, no explanation has hitherto been given of the reason why.

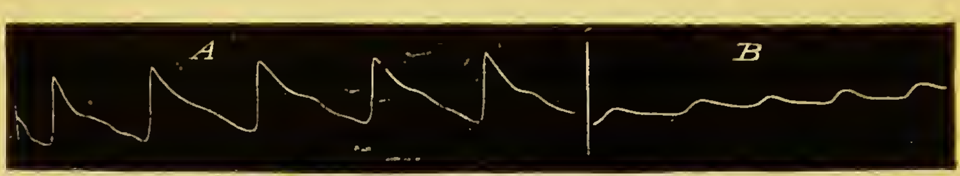

Fig. 10.—Tracings from the radial artery at the wrist: *A* before and *B* after the application of a cloth dipped in cold water round the arm. After Winternitz.

I believe it is simply this: That when heat is applied over the contracted peripheral vessels, it tends to relax them, and thus restores the equilibrium between the different portions of the artery; when cold is applied over the dilated vessels, it causes them to contract, and thus restores the equilibrium between them and the contracted peripheral parts.

The effect of the local application of heat and cold over the course of an artery has been well shown by Professor Winternitz of Vienna. I have seen him place a sphygmograph on the radial artery, take a tracing and then apply cloths dipped in ice-cold water around the arm; the consequence was, that the tracing of the radial artery at once became very much smaller from the contraction of the brachial. On this account cold compresses to the neck are sometimes very useful in headache.

Sometimes warmth to the throat may relieve, but here the *modus operandi* is different; the effect of the warmth in all probability being exerted not directly upon the vessels themselves, but rather upon the sympathetic ganglia in the neck by which the calibre of the vessels is regulated. And here I may perhaps say a word regarding this nervous mechanism. The carotid artery and its branches derive their vaso-motor nerves from the superior cervical ganglion, and to disturbance of the functions of this ganglion are, I believe, due the headache caused by dental irritation. (p. 102.) I do not know that du Bois-Reymond's headaches depended upon a decayed tooth, but I should very strongly suspect it. In his case there was distinct evidence of sympathetic dis-

turbance in the dilatation of the pupil of the affected side. In my own case I have never noticed any dilatation of the pupil, but I have observed a curious transference of pain from the temple to the occiput, and from the occiput to the temple again, so rapid that I think it can only be ascribed to a disturbance of the cervical ganglion. The explanation which I give of it is this: That at one time, the vaso-motor branches of the temporal are affected, at another those of the occipital artery, and the rapid change of the headache from one part to another is due to an alteration in the ganglion itself. The occurrence of occipital headache in place of temporal in my own case attracted my attention to decayed teeth as a cause of occipital headache, and I found that it is by no means unfrequent. The other day I saw a scientific

Fig. 11.—Diagram showing the seat of pain in megrim or occipital headache depending on decayed teeth or defects of the eyes. The shaded area shows the seat of the pain; the spot in each area indicates the seat of tenderness on pressure.

man who was complaining much of occipital headache on the left side. I at once said to him, "The second molar on the left side of your lower jaw is decayed." This statement was not quite correct, for the decayed tooth turned out to be the second molar on the left side of the upper jaw, but it was so near the truth that it astonished him greatly, because it had never occurred to him that there could be any connection between a pain at the back of his head which gave him great annoyance and a decayed tooth which did not trouble him in the least.

In regard to the situation of headache depending upon decayed teeth, I find that a decayed molar in the lower jaw usually gives a temporal or occipital headache, and a decayed molar in the upper jaw causes temporal headache which is rather farther forward than

that caused by the lower jaw. Decayed incisors or eye-teeth are more likely to cause frontal or vertical headache.

Another source of headache closely allied to the teeth is sore-throat. Enlarged and inflamed tonsils are apt to give rise to headache, which usually tends to run up in front of the ears and over the vertex. On one occasion I suffered from inflammation of this sort, and found that at first the pain was diffused all over the head, so that one could not localise it at one point more than another, but that as the inflammation went on, the pain became more localised at the sides of the head and vertex, and gradually extended downwards and became more localised, until it was felt very distinctly in the throat, and hardly in the head at all.

Perhaps a still more frequent source of headache than even decayed teeth are abnormal conditions of the eyes. The headache which comes on after working with the microscope, or after straining the eyes in a picture gallery, is only too well known. It is usually frontal, often extending over the whole breadth of the forehead, but sometimes limited to the forehead above one orbit.

On one occasion I remember seeing a friend who had been working with a microscope, and was suffering from most intense headache. On entering the darkened room in which he was lying, I thought at first that his eyes were jaundiced, but closer examination showed that the apparent yellowness was due to great injection of the vessels of the sclerotic.

It would be going too far to say that frontal headache is always due to an abnormal condition of the eyes, but I believe it is so much more frequently than one would at all suspect. Even the frontal headache which occurs in derangement of the stomach and biliousness is, I think, very frequently connected with an abnormal condition of the eyes to which the indigestion gives rise, for if we press the finger upon the eyeballs during a bilious headache, we not unfrequently find that they are abnormally tense and the intraocular pressure high, so that the eyeball feels almost like a marble under the finger. Curiously enough, too, I have noticed that some persons who suffered from bilious headache in early life begin to suffer from giddiness whenever they become bilious as they grow older. This giddiness during a bilious condition began to come on just at the time when their sight began to alter and they commenced to wear spectacles.

But frontal headache is not the only one which may arise from abnormal conditions of the eyes, for megrim or sick headache is

very frequently associated with, and probably dependent on, inequality of the eyes, either in the way of astigmatism, myopia, or hypermetropia.

Formerly I used to suffer myself from megrim, which might affect either side of the head, but for some years past it has almost invariably affected the left side. My right eye is normal, but the left is hypermetropic, and probably the greater strain that is thrown upon this eye in reading leads to the headache on the same side.

The relationship between megrim and abnormalities of vision has been pointed out by several authors, amongst others Mr. John Tweedy, Dr. Savage, Mr. Higgins, Dr. Brailey, and Mr. Carter.

The good effects of spectacles in megrim was well illustrated in the case of one of my colleagues who suffered very frequently, but after getting a proper pair of spectacles did not get a headache half so often as before.

Although dental irritation and abnormalities of vision are probably the two most common and most important causes of headache, yet the nose and ear are also channels through which external irritation may operate in producing headache, and they must not be overlooked. As far as my experience goes, headache depending upon disease of the nose is at the top of the head, just behind the commencement of the hairy scalp, and headache here should always lead to an examination of the nose.

The frontal headache, however, which occurs in ordinary cold in the head, and which probably depends upon congestion of the mucous membrane lining the frontal sinuses, is known to every one; and Dr. Hack [1] of Freiburg has observed several cases both of megrim and of frontal headache depending upon congestion of the mucous membrane covering the inferior turbinated bones, and he has been able to effect a radical cure in several cases by the application of the galvano-cautery to the inflamed and swollen mucous membrane.

In the causation of headache, however, we have always to consider two things—the condition of the organism generally and the local source of irritation. We have hitherto directed our attention to the local sources of irritation, but local irritation alone will not cause headache. We find that numbers of people have decayed teeth, and yet they suffer neither from toothache nor headache, excepting perhaps occasionally. The source of irritation

[1] Ueber eine operative Radical-Behandlung bestimmter Formen von Migräne, Asthma, Heufieber, u. s. w. Von Dr. Wilhelm Hack, Wiesbaden, Bergmann.

is constantly there, and yet the effect it produces appears to be only occasional. The occasional pain is the reaction of the organism to the irritant, and its intermittent occurrence is probably to a great extent due to the organism being only occasionally in such a condition as to give this reaction. We know that the pain of toothache, for example, is often at once remedied by a brisk purgative, although the tooth remains in the same condition, the purgative having so altered the organism that it no longer responds in the same way to the irritation of the tooth. I use here the vague term *organism* in place of using the more definite one nervous system or cerebral centre of sensation, because we do not at present know the exact mechanism by means of which brisk purgatives produce such an effect. It is highly probable that they do so not directly but indirectly, by modifying the irritation or by clearing away poisonous substances from the intestine.

There are several conditions of the body which tend to give rise to headache more especially; these are indigestion, biliousness, constipation, fever, plethora, anæmia and debility, rheumatism, gout, and albuminuria.

The headache of indigestion, biliousness, and constipation is generally frontal, but it does not always affect the same part of the forehead. As a rule, derived from an exceedingly large experience in the Casualty Department at St. Bartholomew's Hospital, where one sees cases not by tens, but by hundreds and thousands, I have found that frontal headache associated with constipation is removed by the Haustus Magnesii Sulphatis[1] of the hospital Pharmacopœia; that headache just above the eyebrows, and not accompanied by constipation, is relieved by Haustus Acidi Nitro-hydrochlorici;[2] while headache, also unaccompanied by constipation but situated higher up on the forehead, just below or at the commencement of the hairy scalp, is relieved by alkalies, usually given in the form of Haustus Calumbæ Alkalinus (p. 125), twenty minutes before meals. Occipital headache is also sometimes associated with indigestion, and is sometimes relieved also by Haustus Acidi Nitro-hydrochlorici, but in it careful attention should be paid to the condition of the teeth. The headache of fevers is usually frontal, and this is, I

[1] The formula for the Haustus Magnesii Sulphatis is :—

Sulphate of Magnesia, 1 drm.
Diluted Sulphuric Acid, 10 minims.
Syrup of Red Poppies, ½ drm.
Mint water to 1 oz.

[2] The formula for the Haustus Acidi Nitro-hydrochlorici is :—

Dilute Nitro-hydrochloric acid, 10 min.
Spirit of Chloroform, 10 min.
Tincture of Orange peel, 20 min.
Water, 1 oz.

think, associated to a great extent with alteration in the vascularity and tension of the eye. When resident physician in the Infirmary at Edinburgh, I used to see a number of cases of typhus fever, and in this disease the injection of the eyes is well marked; and I was strongly reminded of the eyes of typhus patients by the appearance which, as I have already mentioned, I observed in my friend who was suffering from headache after working with a microscope. Both the injection of the eyes in typhus and headache in fevers generally, whether it be accompanied with injection of the eyes or not, probably depends upon the increased circulation caused by the greater heat of the body in the febrile condition, and by the presence of morbid products or poisons in the blood, which not

Fig. 12.—To show the position of the frontal headache which in cases of constipation is relieved by salines.

Fig. 13.—Showing the position of the frontal headaches relieved by acids and alkalies in the absence of constipation. The lower is relieved by acids, the upper by alkalies before meals. The lower one also indicates the occasional position of headache caused by straining the eyes.

only act upon the eyes, but upon the nervous system and the body generally.

Closely associated on the one hand with the headache of indigestion, and on the other hand with that of fever, is the headache of plethora, which is usually frontal or occipital, and depends both on the powerful circulation which is present in this condition and probably also on the products of tissue waste circulating in the blood.

The headache of anæmia and debility is usually vertical, and is usually associated with feelings of flushing, of heat, or sudden

chilliness, and muscæ volitantes, and not unfrequently also with gastric derangement, evidenced by pain in the epigastrium shooting through between the blade-bones.[1]

The rheumatic headache very frequently is felt over a considerable part of the head generally, and is associated with tenderness over a great part of the scalp. The tenderness is sometimes excessive. This headache is frequently relieved by the administration of iodide of potassium. A formula given me by Dr. Image of Bury St. Edmunds for this headache, and which is very useful, contains 5 grs. of iodide of potassium, a drachm of tincture of valerian, and a drachm of aromatic spirits of ammonia. But although the rheumatic headache assumes very

Fig. 14.—Diagram to show the position of the vertical headache of anæmia.

frequently the form I have just described, it appears to me sometimes to show itself as a frontal or temporal headache, and to be associated with a rheumatic affection of the muscles of the eyes. On one occasion I administered some salicylate of soda for the relief of pains in the limbs which were associated with severe headache. The effect of the salicylate in relieving the headache was almost magical, and I have accordingly tried it in a number of cases since. I found that $2\frac{1}{2}$ grs. of the salicylate of soda, given either alone or with some aromatic spirits of ammonia, every half-hour while the headache lasts, will often after one or two doses cut short the headache, which would otherwise have continued for a whole day or more. I have been unable at present to distinguish

1 This group of symptoms is usually much relieved by the administration of iron with a bitter tonic. The formula for the draught of Quassia and Iron in St. Bartholomew's Hospital Pharmacopœia is:—

Solution of Perchloride of Iron, 15 minims.
Infusion of Quassia, 1 oz.

a gouty headache *per se* from the headache of plethora or indigestion, and should suspect the gouty element only from the patient's family and personal history.

In albuminuria the headache may be frontal, or may be felt as a tight band surrounding the head.

In syphilis its situation may vary, and it is generally recognised by its history, by its being more or less constant, remitting instead of intermittent, and by its frequent association with persistent tenderness at a limited spot.

I may now, in conclusion, sum up shortly the main points I have endeavoured to bring forward in this paper.

Headache is usually the product of two factors—local irritation and general condition.

The chief local causes are decayed teeth and abnormalities of the eye, although diseases of the ear and nose, inflammation of the throat, and local irritation of the pericranium or of the skull in rheumatism and syphilis, are not to be forgotten. Decayed teeth may give rise to temporal or occipital headache when the molars are affected, and also I think to frontal when the incisors are decayed.

The chief abnormal conditions of the eye which cause headache are strain from reading, or working with imperfect light, or for too long a time, myopia, hypermetropia, astigmatism, inequality of vision between the two eyes, and last, but not least, glaucoma.

Besides this, I think that alterations in the circulation and intraocular pressure are frequently produced by bile or poisonous substances circulating in the blood, and that probably also a rheumatic condition, affecting either the eye itself or the muscles which move it, is a not uncommon cause of headache. Where both eyes are equally affected, the headache is usually frontal; but when one eye is more affected than the other, the headache appears either in the form of brow ague or megrim.

In treating any case of headache, therefore, the first thing to do is to see whether the teeth are sound and the eyes normal. If anything is found wrong with either the teeth or the eyes, the defect should be at once corrected. The throat, ears, and nose should also be examined to see if any source of irritation is present there, and the surface of the scalp tested by pressure for rheumatic or syphilitic inflammation. Percussion should also be tried over the head in order to determine whether or not there is any intracranial tumour.

The locality of headache is probably determined chiefly by the local source of irritation, but this differs according to the general condition in a way that it is at present impossible to explain. Thus frontal headache with constipation is usually relieved by purgatives; frontal headache without constipation, just above the eyebrows, is relieved by acids; and a similar headache, situated higher up at the commencement of the hairy scalp, is relieved by alkalies. Vertical headache is usually associated with anæmia, and is relieved by iron. The more or less continuous headache of syphilis is usually best relieved by iodide of potassium; but in order to gain relief the dose must sometimes be much larger than that usually given, and may range from 5 grs. up to 30 grs. for a dose. Smaller quantities of iodide of potassium are usually sufficient to cure the rheumatic headache.

ON DYSPEPSIA.[1]

(' *The Practitioner,*' VOL. XIX., *December* 1877.)

To the healthy body the performance of its functions is a source of pleasure. The strong muscles rejoice in work, and exercise, to use up their superabundant energy, becomes almost a necessity; the brain works easily, ideas flow readily and clearly, and thought becomes a delight. Both bodily and mental work, however pleasant, entail waste which must be supplied, and the pleasures of exercise lead to the pleasures of the table, giving a zest to the plainest food and enhancing the flavour of the most delicate viands. When the day is over, exercise and food give place to the pleasure of sleep, and almost as soon as the head is laid on the pillow, the dreamy delightful languor which succeeds healthy exercise passes into dreamless slumber, from which the sleeper awakes on the ensuing morn, refreshed and strengthened for the occupations of a new day. With such a condition as this we are probably all more or less familiar, and its full enjoyment during a walking tour is, to my mind, one of the greatest charms of an autumn holiday. But unfortunately the conditions of life do not allow men to remain constantly under the favourable conditions in which we are placed during our vacation. Some have hard grinding bodily fatigue, continued hour after hour until the tired limbs can scarcely move, others have the still more exhausting mental drudgery, when, despite the exhausted brain, the closing eyelids, and the aching head, the cramped fingers must drive the pen scratch, scratch, scratch, long past the midnight hour, into the cool grey of early morning. Excessive mental and bodily work thus become not a blessing but a curse, and although they generally bring some compensation by increasing the pleasures of sleep and rest, it is not always so. For although the wise man says "sleep is sweet to the labouring man,

[1] Read before the Abernethian Society at St. Bartholomew's Hospital.

whether he have eaten little or much," yet not unfrequently excessive mental labour drives sleep from the couch, and weary work is succeeded by more uneasy rest. Too much work thus weakens both the muscles and the brain, and causes the exercise of their functions to be performed imperfectly, and attended with suffering, instead of being, as in the healthy state, a source of pleasure. Now the same is true of the digestive organs. Within certain limits, the stomach, liver, and intestines are very accommodating, and will digest much or little food, single dishes or a variety of meats, with great facility, but whenever the tax upon their power becomes too great, they refuse to act, and in various unpleasant ways make known to their master that they are on strike, and either want less work or work of a different sort. As the stomach is that part of the digestive system into which food is first collected, and which therefore is generally the first to suffer from overwork, we will consider its part in the digestion of food first, and the indigestion due to the imperfect performance of its functions, without at present taking up those of the intestines or liver.

We have now so much knowledge of an exact nature regarding the process of digestion, that we are apt to forget how recent is its date, and I therefore think it may not be unadvisable or uninteresting to devote a few minutes to describing the successive steps by which it has been acquired. The knowledge that food was broken up and partially dissolved in the stomach must have been early acquired, for the ancients as well as the moderns sometimes overtaxed their stomach with food or drink, and led that organ to reject the meal which had shortly before been consumed. In the paintings on Egyptian tombs,[1] we see ladies depicted who are suffering in this way; and although they might not be themselves in such a condition as would lead them to examine very closely into the nature of the vomited matters, it could hardly escape the attention of the attendants or of the physicians who might be called in, and who sometimes, indeed, produced vomiting,[2] that these matters consisted of the broken down and partially dissolved foods which had constituted the last meal. But how this solution was effected long remained a mystery. Some said that it was effected by the stomach grinding down the food in the same manner as the gizzard of a bird; but the ancients generally

[1] Wilkinson's *Ancient Egyptians*, 1854, vol. i. p. 52.

[2] Wilkinson, *Op. cit.*, vol. ii. p. 350.

seem to have had the idea that it was effected by heat and moisture leading to a sort of putrefaction,[1] or by a secretion from the stomach with special solvent powers.[2]

The experiments of Réaumur in 1752, and of Spallanzani in 1783, showed that the food was not simply ground by the stomach, for substances enclosed in perforated metallic balls, and thus protected from any mechanical action of the gastric walls while exposed to the solvent action of the gastric juice, were found to be dissolved when the metal case was after a certain time withdrawn from the stomach by means of a string attached to it. The theory of putrefaction was also disposed of by Spallanzani,[3] who found that instead of this process going on in the stomach, it was immediately checked when substances in which it had begun were introduced into the organ.[4] But it is highly probable that the ancients meant something different from ordinary putrefaction, although they may have used the name to designate the process which takes place in the stomach during digestion, and Boerhaave propounded the theory that digestion was a process of fermentation. The questions, therefore, remained to be solved —Is digestion a simple solution in the gastric juice? or is it a change in the constitution of the food by oxidation or otherwise?[5]

In most experiments the gastric juice had been obtained in an impure state, and its admixture with saliva or mucus had rendered its reaction doubtful, but Carminati, in 1785, determined that it was acid when obtained pure during digestion, although nearly neutral during fasting in animals. Prout, in 1824, found that the acid was hydrochloric, and Tiedemann and Gmelin, in 1827, finally confirmed the results of Carminati. They were inclined to attribute the solvent power of the gastric juice to the acid it contained, but their own experiments, as well as those of Johannes Müller, and still more of Dr. Beaumont, showed that acid of the same strength had nothing like the solvent power of the gastric juice, and that this secretion must therefore contain a peculiar solvent principle. This Eberle supposed to be the gastric mucus, but a few trials proved that this mucus alone would not dissolve the food, and that digestion took place

[1] Hippocrates, etc., Haller's *Physiol.* t. vi. p. 322.

[2] *Paulus Aegineta*, vol. i. p. 91.

[3] Spallanzani, *Expériences sur la Digestion*, Genève, 1783, p. 90.

[4] Spallanzani, *Op. cit.*, p. 310.

[5] Tiedemann and Gmelin, *Journ. de Physiol.* vii. 1827, p. 144.

only when it was combined with acid. The next step was taken by Schwann in 1836, and by Wasmann in 1840. They showed that it was not mucus in general but a special substance, pepsin, contained in the mucus of the stomach, which digested albuminous matters when combined with acid. The researches of Brücke have shown what the proper strength of the acid is, and that when it is either too strong or too weak digestion is hindered. The requisites for the rapid digestion of albuminous matters in the stomach, then, are an abundant supply of gastric juice and its proper composition as regards the proportion of acid and the amount of pepsin present in it. These requisites are supplied in the healthy stomach, which secretes a large quantity of active juice during digestion; but in disturbed and diseased conditions, either of the organ itself alone or of the whole system, they are more or less wanting, and digestion is imperfectly performed—we have, in fact, indigestion.

We owe our knowledge of the condition of the stomach in great measure to a fortunate accident which established a gastric fistula in a young man, and enabled observations to be made on him such as we can usually make only on animals—observations which were, however, imperfect, and have since been extended as well as confirmed by gastric fistulæ artificially established in dogs. A young Canadian, Alexis St. Martin, was wounded by a charge of duck-shot, which carried away the muscles on the left side of the thorax for several inches, along with the anterior half of the sixth rib, broke the fifth, and lacerated the left lung, stomach, and diaphragm. Notwithstanding the extent of his injuries, he finally recovered under the care of Dr. Beaumont; but the stomach became adherent to the abdominal wall, and preserved a permanent opening, which was usually stopped up by a valve of mucous membrane. This valve could be readily pushed back by the finger and the interior of the stomach distinctly seen. After St. Martin's recovery, Dr. Beaumont took him into his service and made numerous observations upon him, which, as I have already said, have been of the greatest value.

According to Dr. Beaumont, "the inner coat of the stomach, in its natural and healthy state, is of a light or pale pink colour, varying in its hues according to its full or empty state. It is of a soft or velvet-like appearance, and is constantly covered with a very thin transparent viscid mucus, lining the whole interior of the organ. Immediately beneath the mucous coat, and apparently

incorporated with the villous membrane, appear small spheroidal or oval-shaped granular bodies, from which the mucous fluid appears to be secreted." On the application of aliment, the action of the vessels is increased, the colour heightened, and the vermicular motions are excited. The small gastric papillæ begin to discharge a clear transparent fluid, which continues rapidly to accumulate as aliment is received for digestion. "This fluid is invariably distinctly acid. The mucus of the stomach is less fluid and more viscid or albuminous, and sometimes a little saltish, but does not possess the slightest character of acidity. On applying the tongue to the mucous coat of the stomach, in its empty unirritated state, no acid taste can be perceived. When food or other irritant has been applied to the villous membrane, and the gastric papillæ excited, the acid taste is immediately perceptible."[1] It must be noted, however, that this acidity, though distinct, is not great, not such as to set the teeth on edge. The experiments of Bernard on dogs have given the same results as those just described, but have shown besides that while moderate stimulation of the stomach causes secretion, great irritation has an entirely opposite affect. For example, when the mucous membrane was gently stroked with a glass rod it became rosy red and secreted juice abundantly, but when violently rubbed the colour disappeared, it became pale, the secretion of gastric juice stopped, that of mucus seemed to be increased, and the animal seemed sick, and began to vomit. This experiment throws considerable light on the relation between the condition of the stomach and the appetite, and enables us in some degree to diagnose the condition of the stomach from the answer we get to our first question regarding the digestion of our patients—How is your appetite? Various opinions have been held regarding the cause of hunger, some attributing it to the friction of the sides of the empty stomach against each other, others supposing it to be due to the gastric juice acting on the mucous membrane in default of anything else to attack. The real cause seems to be twofold. 1st. A certain condition of the stomach, probably consisting in distension either of the lymphatics or capillaries of the mucous membrane, which is relieved when food is ingested and secretion begins. 2nd. A condition of the system which is not removed by the mere presence of food in the stomach, but requires for its alleviation the absorption of nutritive material into the blood. This second condition may be observed

[1] Beaumont, *Physiology of Digestion.* 2nd ed., Burlington, 1847, p. 95.

in children suffering from tubercle of the mesenteric glands, where, owing to the imperfect absorption, a voracious hunger seems to consume the little sufferer, notwithstanding the quantities of food with which its stomach is constantly filled. The first cause of hunger or appetite, for they are merely gradations of the same condition, is the commonest, and the one with which we are at present concerned. Normally the stomach seems to prepare itself at regular intervals for the work it has to do, and as meal-time approaches the minute vessels probably become distended, and a feeling of appetite certainly appears. In some persons the time when this feeling comes on can be modified by mental impressions. If they know they are to dine at seven instead of at six, the appetite appears a short while before the time fixed for the meal, but if they think they are to dine at six and do not get dinner until seven, the expectant stomach begins to crave at six, and causes much discomfort during the ensuing hour while its wants are unsatisfied. In some conditions of the body we find that there is no appetite at first, but after a mouthful or two the desire to eat comes on, and the person rises from table after a full meal. Although I have not observed that Dr. Beaumont mentions this condition as occurring in St. Martin, yet we should be inclined to associate it with a mucous membrane paler and more flaccid than usual.[1] The lymphatics and capillaries, instead of being full before the meal, would only become so when the circulation in the stomach was increased by the introduction of food, and their distension, after the first few mouthfuls, in this debilitated condition of the stomach would become equal to that in the healthy mucous membrane before any food had been taken at all.

In other conditions again we find that the patient has, as he says, a good appetite and feels very hungry before meals, but after the first mouthful or two he is satisfied, and cannot eat any more. Here we in all probability have a condition of congestion greater than normal, so that instead of mere appetite positive hunger is felt before meals, but as soon as the first mouthfuls are taken, the increased vascularity which they induce raises the irritability of the stomach, and the stimulus of the food acts upon the mucous membrane in the same way as rough rubbing did in Bernard's experiment, destroying the appetite and even producing nausea. As a general rule, indeed, whenever the appetite becomes unusually good without any apparent cause, we may look out

[1] Beaumont, *Physiology of Digestion*, Burlington, 1847, Expt. 45, 3d. Ser.

for a so-called bilious attack, for if the irritated condition of the gastric mucous membrane, which is at first felt as appetite, goes on increasing it soon proceeds to anorexia, nausea, and vomiting.

An example of this may be given from Dr. Beaumont's observations. On examining the stomach of St. Martin one day, four hours after breakfast, and an hour after the chyme resulting therefrom had passed through the pylorus, he found that "several red spots and patches abraded of the mucous coat, tender and irritable, appeared over the inner surface.[1] The tongue too had upon it a thin whitish fur. Yet his appetite was rather craving." Two days after this Dr. Beaumont introduced some food in a muslin bag, through the aperture, into the stomach, and on withdrawing it five hours afterwards, found that it came from near the pylorus, and was covered with a coat of mucus and yellow bile. "The contents of the stomach," he says, "have been unusually acrid since yesterday morning, and St. Martin complains of unusual smarting and irritation at the edges of the aperture; countenance sallow, tongue covered with a thin yellowish coat; and several deep red patches on the inner coat of the stomach; does not feel his usual appetite." Had St. Martin been left to himself and continued the diet of the previous days, consisting, as it appeared to do, of pork, steak, and fried sausages, we should probably have had him suffering from vomiting, and possibly sick headache, but Dr. Beaumont dropped into his stomach twelve grains of blue pill and five cathartic pills, which operated next morning with the effect, Dr. Beaumont says, of removing the symptoms and restoring healthy sensations and functions. Had no pills been given the condition of the stomach next day would probably have been such as Dr. Beaumont describes on another occasion, when the sick headache was actually present. He had been introducing various articles of food, amongst others fat pork tied to a string, into St. Martin's stomach, and two or three hours afterwards found the smell and taste of the fluid from the stomach to be slightly rancid, and St. Martin complained of considerable pain and uneasiness at the stomach, general debility, and lassitude. The next day the distress at the stomach and pain in the head continued, accompanied by costiveness, a depressed pulse, dry skin, coated tongue, and numerous white spots or pustules resembling coagulated lymph spread over the inner surface of the

[1] Beaumont, *Physiology of Digestion*, Burlington, 1847, Expt. 17, p. 180, 3d. Ser.

stomach. Dr. Beaumont accordingly dropped into the stomach half a dozen calomel pills,[1] containing four or five grains each, which in about three hours had a thorough cathartic effect, and removed all the foregoing symptoms, and the diseased appearance of the inner coat of the stomach.

When looking at a patient's tongue I have often wished that people wore windows in their bodies, and that one could see into their stomachs as readily as into their mouths. This wish is to some extent gratified by a perusal of Dr. Beaumont's observations, for in the three which I have just quoted he gives us a picture of three very common conditions.

In the first we have a craving appetite, tongue showing a thin whitish fur, and stomach with several red spots and abraded patches.

In the second we have loss of appetite, thin yellowish fur on the tongue, sallow, or, as we should often term it, bilious countenance, and stomach showing several deep red patches.

In the third the appetite is not mentioned, but we may conclude that there was none, as St. Martin had distress and uneasiness in the stomach, the tongue was coated, there was debility, lassitude, costiveness, depressed pulse, dry skin, and headache. The stomach showed numerous white spots or pustules.

Curiously enough, however, the stomach sometimes showed signs of extensive disturbance without any apparent affection of the general health. This was especially noticeable after drinking spirits too freely. The mucous membrane then presented an erythematous appearance and livid spots, from the surface of which exuded small drops of grumous blood, numerous patches of aphthæ, a thick coating of mucus, and the gastric juice mixed with thick ropy mucus or muco-purulent matter slightly tinged with blood resembling the discharge from the bowels in dysentery. This condition of the stomach was accompanied by a thin, yellowish brown fur on the tongue, and uneasy sensation and tenderness at the pit of the stomach, and some vertigo with dimness and yellowness of vision on stooping down and rising again, and a sallow countenance, but otherwise he felt well and had a good appetite.[2] These four observations of Beaumont's describe the symptoms and appearances of the tongue which we usually meet with in cases of transient indigestion, and depict the condition of the stomach which he found associated with them.

[1] Beaumont, *Physiology of Digestion*, Burlington, 1847, Expt. 1, p. 118, 2nd Ser.
[2] *Ibid.* Burlington, 1847, p. 252.

We have now to consider the causes which induce these appearances, and we may shortly describe them as irritants of the stomach—

a. From excessive quantity.

b. From improper mechanical or chemical qualities.

A meal excessive in quantity will act as an irritant because a longer time will be required for the stomach to dissolve it, and during all this time the undissolved pieces of food are being rubbed up and down the mucous membrane and irritating it mechanically.

An improper quality of food may have a similar action mechanically. Suppose a lump of cocoa-nut to be eaten, the pieces when swallowed will be absolutely unacted on by the stomach, however long they remain there, and at the time when the organ ought to contain nothing but a soft pulpy chyme, which it would pass on to the duodenum, its walls are stimulated by the unaccustomed presence of the bits of kernel, hard and unyielding as at the moment they were introduced.

Other substances are injurious on account of their chemical properties. Alcohol acts as an irritant by its chemical qualities, producing, when its use is continued, very extensive alterations in the mucous membrane, and it is to be remembered, that some substances which are not in themselves irritant may become so from changes which they undergo themselves, or occasion in other foods after their introduction into the stomach. Thus, fat pork is not an irritating substance—far from it; but it may become rancid in the stomach, and the fatty acids thus liberated may act as powerful irritants. Some cheese is indigestible on account of its insolubility and hardness, in the same way that cocoa-nut is, but other cheeses not liable to this objection may prove irritant by inducing the formation of butyric acid from the sugar taken into the stomach in the food or formed there by the action of the saliva and starch which have been swallowed together. Butyric acid appears to be the cause of that uncomfortable feeling known as heartburn, for Dr. Leared found that a pill of some sweet inert substance dipped in this acid and swallowed reproduced the sensation of heartburn exactly. A very acid condition of the contents of the stomach acts as an irritant and may cause vomiting, the vomited matters being so sour as to set the teeth on edge. What the exact cause of this sourness is I do not know, whether it be hydrochloric, lactic, butyric, or other acid, nor do I know exactly the cause of

its production, but I well remember having a most violent sick-headache and an attack of vomiting after drinking some new beer which I suppose continued in my stomach the fermentation which ought to have been complete before it was drunk, and which at the same time induced other ingredients of my dinner to join it in the process.

It is a question not yet completely solved how far the mucus of the stomach acts as a ferment in producing acidity, and also whether abnormal substances formed in the intestine are absorbed from it by the vessels, secreted from them by the gastric glands, and poured out into the cavity of the stomach, just as we know that iodine is.

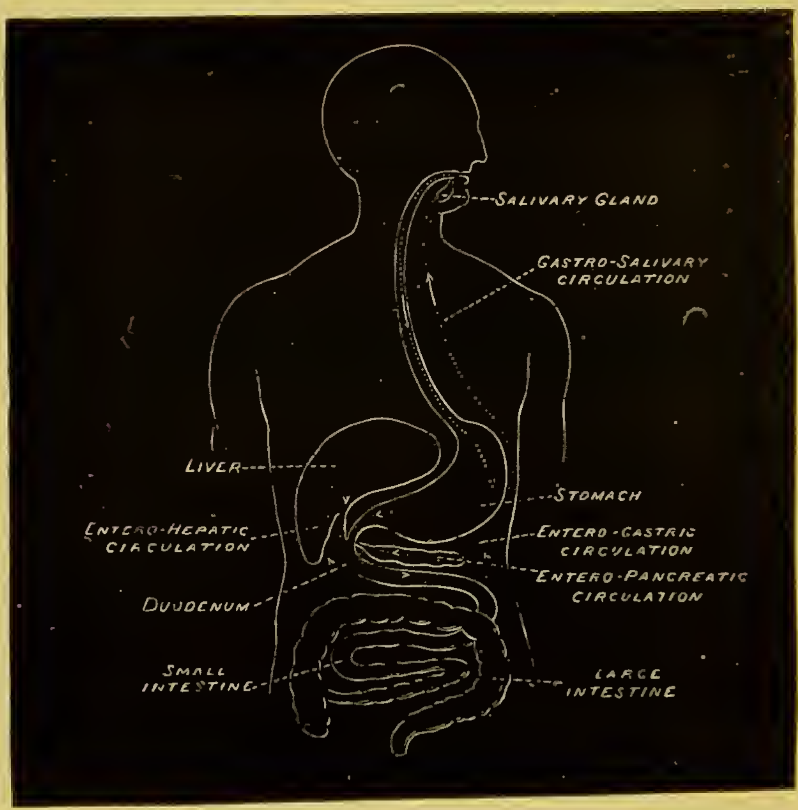

Fig. 15.—Diagram showing absorption from one part, and excretion from another part of the intestinal canal.

Treatment of Temporary Indigestion.—The conditions of the stomach hitherto mentioned, as well as the symptoms that accompany them, disappear when little food and that of a bland and unirritating nature is given for a short time, but recovery is greatly quickened, as we see from Dr. Beaumont's experiments,

by the administration of a purgative. Now comes the query, Does this act reflexly upon the stomach through its nerves, or does it clear away from the intestine substances which are being absorbed from it, carried to the gastric walls, and excreted by them just as tartar emetic would be, and causing like it irritation of the mucous membrane? (*Vide* entero-gastric circulation in diagram, and compare p. 178.)

For my own part I am inclined to take the latter view, for on one occasion Dr. Beaumont finding that St. Martin's stomach was out of order, poured in an ounce of castor-oil. This did not purge, and the stomach continued as before. He then gave some calomel, which produced purgation, and the morbid appearances were quickly removed.

The question also arises, to what extent were the erythematous patches, and especially the lividity, due to obstruction to the circulation of the blood through the liver by biliary congestion? Dr. Beaumont says nothing about the existence of piles in St. Martin coincidently with this affection of the stomach. Had he done so it might have given us some useful hints regarding the pathology, obstruction to the portal circulation being likely to manifest itself in the veins of the rectum as well as those of the stomach.

When the irritating substances leave the stomach they may produce a similar effect upon the intestine and cause griping and diarrhœa.

Having said so much regarding slight acute indigestion, I must treat very shortly the subject of gastritis. Acute gastritis, such as is produced by irritant poisons, I will completely pass over, and only say a few words regarding sub-acute gastritis, or gastric catarrh. If any one is obliged to inhale fine irritating dust for some time the mucous membrane of the bronchial tubes becomes inflamed, secretes a quantity of mucus or muco-purulent matter, and the inflammation is accompanied by more or less pain and rawness in the chest and attempts to expel the mucus by coughing. Not unfrequently the same condition comes on after exposure to a draught, although no irritating substance has been inhaled. The mucous membrane of the stomach and that of the lungs are not unlike in their reaction to irritation or cold. I have already mentioned that after St. Martin had been freely partaking of spirits for some days Dr. Beaumont found his stomach inflamed, bleeding, and partly filled with ropy mucus and muco-purulent

material. From the ample experience which one gets at this hospital I think we may safely say that had St. Martin gone on drinking for some days more he would probably have got his stomach into such an irritable condition that he would have felt considerable pain and tenderness to pressure in the epigastrium, every morning when he rose he would have vomited some of the mucus which it had secreted over night, and he would have vomited the greater part of each meal shortly after he had taken it. The appearances presented in such a condition would probably have been the same as those actually observed by Dr. Beaumont, but somewhat intensified.

But a similar condition may occur in the stomach from exposure to cold or to a draught, just as in the case of the lungs, although no irritating substance has been swallowed.

How draughts act in producing this condition is a subject not unworthy of the Society's attention, but time would fail me were I to attempt to develop a theory of catching cold either in the stomach or lungs, in this paper.

Treatment.—The treatment which is very successful is to give about ten grains of bismuth with ten of magnesia, in a little mucilage three or four times a day before meals. If the vomiting be excessive it is well to combine a few drops of hydrocyanic acid and some bromide of potassium, and if the pain at the epigastrium be great a warm poultice or even a mustard plaster should be applied.

We must now pass on to the chronic forms of indigestion, and shall first take that of chronic gastric catarrh. The condition of the stomach here is just that presented by St. Martin after his alcoholic indulgence, but when it has continued long the structure of the stomach becomes more or less altered, the gastric glands undergoing fatty degeneration, the connective tissue becoming increased and the mucous membrane firmer.

The symptoms are such as we should expect. There is either little appetite or a craving appetite, easily satisfied—sometimes instead there is a feeling of emptiness in the epigastrium or nausea, although there is little vomiting. From the irritable condition of the stomach there is often pain coming on shortly after food, or more or less constant, but increased by food. The secretion of gastric juice being imperfect, the food is slowly digested and undergoes decomposition, forming gases and acids, and thus giving rise to flatulence and heartburn. The constant

discomfort and pain makes the patient irritable, and the imperfect digestion of the food as well as the diminished quantity taken on account of the pain caused by it lead to muscular weakness, and mental languor and depression.

The bowels are frequently constipated, or may be subject to alternate fits of constipation and diarrhœa. The pain complained of is partly due to the tender condition of the stomach, but it is also caused to a great extent by distension of the stomach with flatus.

This condition is very frequently seen in middle-aged or elderly women who come to the hospital complaining of "windy spasms." On inquiring more closely into their symptoms they tell you that they have "pain in the pit of the stomach, striking through between their blade-bones," and further questions will elicit most of the other symptoms already described. There are two remedies in the Hospital Pharmacopœia which work wonders in such cases: the Haustus Gentianæ cum Rheo., and the Haustus Calumbæ Alkalinus.[1]

Both of these draughts contain bicarbonate of soda and a vegetable bitter. When given before meals the alkali stimulates the secretion of gastric juice, while the bitter is supposed to lessen the secretion of mucus. The food thus becomes more rapidly digested, less acid and less gas are formed, and the spirit of chloroform, by acting as a carminative, enables such gas as is formed to be more readily expelled. When taken after meals this beneficial action of the alkali is lost, and it becomes injurious rather than beneficial, except in cases where excessive acidity is developed during digestion.

In regard to the pathology of acute attacks of indigestion, I

[1] The formulæ for these are :—

Haustus Gentianæ cum Rheo.

Infusion of Rhubarb	½ fl. ounce.
Tincture of Gentian	30 minims.
Bicarbonate of Soda	10 grains.
Spirit of Chloroform	10 minims.
Peppermint water	to 1 fl. ounce.

Dissolve and Mix.

Haustus Calumbæ Alkalinus.

Bicarbonate of Soda	10 grains.
Tincture of Orange Peel	30 minims.
Infusion of Calumba	to 1 fl. ounce.

Dissolve and mix.

mentioned that the livid spots observed by Dr. Beaumont might possibly be connected with obstruction through the liver. An additional argument in favour of this view is offered by the fact that chronic catarrh, such as I have just described, may not only result from repeated or constant irritation of the stomach by alcohol, tea, spiced and indigestible foods, &c., or from cancer or ulceration of a part of the stomach, but also from interference with the portal circulation, as in disease of the liver.

Lastly, we will shortly consider atonic dyspepsia. This condition probably corresponds to that temporarily observed by Beaumont, where the mucous membrane was pale and flabby. The symptoms are here also such as we should expect, the appetite being almost absent, yet the patient is often able to eat a fair meal. The stimulus of the food, however, in a stomach below par does not cause a sufficient secretion of gastric juice, and possibly also the composition of the juice is not all it ought to be; the digestion consequently goes on slowly, there is heaviness and weight at the epigastrium after meals, and the belly becomes tumid from the generation of gas. Eructation gives relief, but not unfrequently is accompanied by heartburn, acids being formed as well as gas, and coming up together.

The symptoms, in fact, are those of imperfect digestion, already described under chronic gastric catarrh, with this difference, that there is no marked pain and tenderness at the epigastrium, and the tongue, instead of being red or covered with fur, through which enlarged papillæ project, is rather pale, flabby, moist, and marked with the teeth at the edges.

This condition depends on weakness of the circulatory and nervous systems. For the secretion of gastric juice demands not only an action of secreting cells, but also a full supply of rich blood to supply the materials needed. Both the cells and the blood-vessels are under the direction of the nervous system, and unless it responds to the stimulus of food, the cells do not secrete, the blood-vessels do not dilate, the juice is not poured out, and digestion does not take place.

The treatment in such a condition is somewhat the same as in chronic catarrh, viz. alkalies and bitters; but in addition we must attend to the general condition of the patient, and give iron to improve the condition of the blood, and the nutrition of both cells and nerves. Strychnia or nux vomica also is a most useful adjunct, as it increases the excitability of reflex centres, including those

which preside over the vascularity of the stomach and the secretion of its cells, and thus renders them more ready to respond when the stimulus of food is applied to them. At least this is the theory I have formed to explain the undoubted advantage which we derive from its use in such cases.

In this paper I have not treated the subject of dyspepsia in the way in which it is usually found, either in text-books or lectures, but have preferred to fix upon a few points which may lead to an active discussion, and to a thorough knowledge of the connection between the symptoms we find in our patients and the conditions of the stomach which lead to them.

ON THE USE AND ADMINISTRATION OF FAT.[1]

(*'The Practitioner,'* VOL. XX., *March* 1878.)

SOME time ago, an attempt to swim across the Channel was made by Johnson, then the champion swimmer of England. At first he made good progress, but at length his strength seemed to fail, and when he was at last lifted into the boat by those who accompanied him, his limbs hung down utterly powerless. It appeared that this was not so much due to real muscular exhaustion, as to the effect of cold. We know that when a muscle is cooled down very much, the nerves which supply it refuse any longer to convey impulses to it from the nervous centres, so that however powerful the effort of the will may be, the muscles will no more respond to it than they would in an animal poisoned by curara. Prolonged exposure to the cold water of the Channel appeared to have induced this state in Johnson's muscles. Afterwards, when Captain Webb proposed to attempt the feat, I felt quite certain in my own mind that he would fail, not because I doubted his powers of endurance, but because I thought that his muscles must needs be affected by the cold in the same way as were those of Johnson. But, as the event showed, I was quite mistaken, for Captain Webb succeeded in his attempt. In coming to my conclusion, I had left out of account the influence which a thick coat of subcutaneous fat might have in protecting a human being from the action of external cold, just as it does the porpoise or whale, this coating being no doubt aided by the porpoise oil with which the skin of the swimmer was lubricated, and which still further prevented the loss of heat. One use of fat, in the economy, is to act as a protective against external cold. This protective power appears also to be useful to the individual by diminishing his chances of catching cold on exposure to draughts,

[1] Read before the Medical Society of London, Dec. 10, 1877.

and where the coating of fat under the skin is deficient or absent, we must supply its place by non-conducting articles of clothing. We rarely think of covering the chest of a fat person with chamois leather or thick flannel, but these coverings are both pleasant and useful for thin or emaciated persons. In cold climates, a coating of subcutaneous fat all over the body is a useful protection, but in warm weather, or in hot climates, it becomes exceedingly oppressive, as one may see by watching very stout persons or fat animals during the heat of summer. In some animals which are natives of tropical climates, or of regions in which the summer heat is great, although the cold during winter may be extreme, we find that fat, instead of being distributed over the body with more or less uniformity, is collected in huge masses at certain parts. In the zebu, or Brahmin bull of India, in the yak of Tartary, in the buffalo of the American prairies, and in the camel of the African or Asiatic deserts, we find large humps upon the back, which consist almost entirely of solid fat. On looking at a camel, we see that the hump is usually firm and solid, projecting stiffly from the back, but at times it may appear limp and loose, swaying helplessly from side to side, and doubling up like a half empty bag. On inquiring as to the reason of this, we are told that so long as a camel is well fed, the hump remains firm and solid, but that when the animal's food is insufficient it becomes thin, loose, and flabby, a great part of the fat being absorbed from it, while if the camel be kept absolutely without food for days, the protuberance will almost entirely disappear. When, on the other hand, food is again given, the hump regains its former dimensions, so that its use is apparently that of a reservoir of food, which may be drawn upon when the daily aliment is insufficient. We all know that the same thing takes place with regard to subcutaneous fat, as with the fat of the camel's hump, and that whenever the fat assimilated is insufficient for the wants of the economy, the person or animal becomes leaner and leaner, until the fat has almost entirely disappeared. To the question, Where has this fat gone? it is difficult to return a very definite answer. Probably some of it has undergone combustion, without being formed into any other tissue, but another part of it has probably gone to supply the waste of some more important organs, which thus are enabled to live, parasite-like, at the expense of the fat. The blood contains only about one-half per cent. of fat, the muscles more than 3 per cent., the

brain 8 per cent., and the nerves 22 per cent. Yet in spite of the large proportion of fat contained in the nerves, they are amongst the last organs to suffer under the process of starvation, and probably their waste is supplied by the fatty matters absorbed from subcutaneous cellular tissue, and brought to them by the blood. The different tissues probably require very different amounts of fat, and the high percentage of fatty matters contained in nervous substance indicates the necessity of fat for the proper performance of the functions of the nerves. Fat may be supplied to the body by various kinds of food—fatty, starchy, saccharine, and albuminous. For although these do not all contain fat, they are all capable of being converted into fat, to a greater or less extent, by the organism. It is not certain that the various fats formed from these different kinds of food have precisely the same composition. It is well known to feeders of cattle that fats differ in quality according to the food upon which the animal has been fattened, and that while, for example, the fat which horses lay on when fed upon corn is tolerably permanent, that produced by feeding on grass is soft, and quickly disappears when the animal is set to work. In his book on *Fat and Blood, and How to Make Them*, Dr. Weir Mitchell quotes the remark of an old nurse that "some fat is fast, and some is fickle, but cod-oil fat is easily squandered." One would suppose at first, that the fat taken in the food would be stored away in the adipose tissue without undergoing any change, but this does not seem to be the case. It appears rather that the fats are split up and modified in such a way during digestion and absorption, that, when deposited in the tissues, their composition becomes tolerably definite in each class of animal. Thus, the composition of the fat of a man will differ from the composition of the fat of a dog, although both may have been fed upon the same mutton suet, the composition of which differed from that of the fat of either. Subbotin found that when a dog was kept without food until all the fat had gone from the body, and was then fed with palm-oil containing palmitine and olein, but no stearin, it nevertheless laid on fat which contained stearin, although in somewhat less than half the normal quantity. When palmitine and stearin were given to a starving dog, but no olein, the fat it laid on contained even more than the normal quantity of olein though less stearin.

It would almost seem, then, that fat rapidly laid on, as in the case of these animals, contained a greater proportion of olein than

normal, whether this were present in the food or not. That fat may be formed from other kinds of food, such as starchy or saccharine, has been shown by Lawes and Gilbert, who found that in fattening pigs, four or five times as much fat was produced among the animals as was contained in their food, and by Liebig and others, who found that bees could form wax, which is a kind of fat, although they were fed on nothing but sugar. This is supported also by the fact that negroes grow fat during the time when sugar-canes are ripe, and when they are constantly sucking the saccharine juice. That fat may be formed from albuminous substances has been clearly shown by Voit and Bauer, in their researches on fatty degeneration, of which we will speak more particularly hereafter. Before the different kinds of food can become available for the wants of the tissues, they must be brought into such a condition as to pass through the walls of the intestine into the blood, and be carried about through the circulation. The starch is converted into soluble sugar by the ferments of the salivary glands and pancreas in the mouth and small intestine, although while it remains in the stomach this change is diminished or arrested by the acidity of the gastric juice. How the sugar yielded by the starch is converted into fat we do not precisely know, although it seems probable that the change of part of it at least into lactic or butyric acids may be one part of the process. The albuminous matters are converted into peptones by the stomach and pancreas. Some of these peptones are further split up during pancreatic digestion, so as to yield leucine, which belongs to the group of fatty bodies. The fats themselves are partially emulsionised, as well as partially saponified, by the pancreas. They then pass either through or between the epithelial cells, which cover the villi, into the lymph spaces in their interior, and thence through the lacteals, mesenteric glands, and thoracic duct into the general blood-current. The amount of fat in the blood may be very considerably increased by food. In a dog, which had fasted for four days, a diet of bread raised the proportion of fat in the blood from 2·6 in the thousand to 3·1; meat raised it to 3·8; and suet and starch to 4·1, a most important observation, to which we shall again have occasion to refer. All these foods, as we thus see, raise the proportion of fat; but besides the fat they all supply other substances to the blood which may be beneficial, but which, in excess, may prove more or less injurious. Thus bread supplies sugar as well as fat. If this

sugar undergo the proper changes in the body, it is useful, but if it be in such excess that its combustion is insufficient, it will produce thirst and the other symptoms which we meet with in glycosuria. If the appetite or digestion will not allow of the consumption of sufficient bread to produce this, we may have a deficiency of fat. Meat also, as we have seen, produces fat, but supplies also a large quantity of nitrogenous material which may, like the sugar, prove injurious when in excess. We usually suppose that a diet of meat is the best cure for failing strength, and for weakly persons we are accustomed to recommend beef-tea whenever they feel faint. But Ranke observed that an exclusively meat diet, instead of producing strength, caused weakness and muscular fatigue, the excess of waste nitrogenous products proceeding from the decomposition of this food in the organism seeming to act as a muscular poison.

In order, then, to keep the balance true, and supply the wants of the various tissues without having any excess of waste products, we must have an admixture of various kinds of food, and if one or other be deficient, we either throw additional work upon the organism by making it consume more than a fair share of another sort, and excrete the residue which it does not want, or the tissues and organs which most require the missing food will suffer in consequence. Now, the food which is more frequently deficient than any other is fat, and this may be either because the fat cannot be obtained, or because it cannot be digested. The late Dr. Hughes Bennett used to say that two of the main causes of tuberculosis were the dearness of butter and the abundance of pastrycooks. For fat is an expensive article of diet,—well-fed meat is dearer than badly-fed and lean meat. Butter is expensive, and amongst poor families its place is very often taken by molasses or jam, which no doubt gives a relish to the bread, and is enjoyed by the child, but does not supply the place of butter as a food. Hence, amongst the lower classes, both children and adults suffer because they are unable to obtain a sufficient proportion of fat in their food. The pastrycooks whom Dr. Bennett accused of causing tuberculosis amongst the upper classes, did it, he said, by disordering the digestion, of young girls especially, by puff-paste, and other things of that sort, and thus spoiling their appetite for food, and especially for the fat which they might obtain in abundance if they liked. The result is the same in both classes, for unless the fat be absorbed and assimilated, the result is the same as if the

patient could not obtain it. But we notice that in both upper and lower classes there are numbers of children who refuse fatty food, although their parents or guardians are sufficiently careful to prevent them from injuring their digestions by puff-paste, or anything of the kind. There are many children who will utterly refuse to eat a piece of fat meat. They will eat the lean, but carefully cut off every scrap of fat, and lay it at the side of the plate, and will submit to severe punishment rather than eat it. Some persons are in favour of punishing such children, and compelling them to eat fat, but such a course I regard as a total mistake. The instinct of the child is perfectly right, and its indications ought not to be disregarded. If the fat be swallowed under compulsion, it generally disagrees with the child, and makes it sick, as the poor thing well knows. In such cases the proper thing to do is to give the fat in another form. If any one of us were to swallow a lump of butter, by itself, it would very probably make us sick; but if we spread the same butter upon pieces of bread, we can take it not only without discomfort, but with enjoyment. Professor Hugo Kronecker once illustrated this to me very strikingly. He said: "Suppose you get a piece of butter, and are asked to make a sandwich, would you take the whole of the butter, spread it on one slice of bread, and then put the other unbuttered slice on the top of it? If you did, your sandwich would not be half so palatable as if you divided your butter, spread it upon both slices, and then put them together." The reason of this is simple, for in the latter case we get the fat in a much finer state of subdivision, and the more finely it is subdivided, the more do we enjoy it, and the more readily is it digested. A piece of solid butter swallowed alone would melt in the stomach, float about without undergoing digestion, and would probably begin to decompose and yield acrid fatty bodies, which would irritate the stomach and cause sickness. When finely divided by admixture with particles of bread, it would form a creamy mass, which would quickly pass into the duodenum, and be digested and absorbed. In the same way, these very pieces of fat which a child will cut from its meat and put aside, may be rendered quite palatable by being mixed with flour or potatoes. A piece of fat bacon, or the liquid fat in the plate, which would certainly make the child sick if swallowed alone, will be taken with great relish if chopped up finely and well mixed with a mashed potato. Whatever the fat may be which we wish a person

to swallow, we should endeavour, by every means in our power, to subdivide it minutely, if there be the least difficulty in digesting it. Besides this, we ought to seek to maintain this state of subdivision in the stomach. For although the fat may be finely subdivided at the time it is swallowed, yet during its sojourn in the stomach it may be melted by the warmth of the body, and the globules gradually agglomerating may again form a solid mass, which will have somewhat the same effect upon the stomach as if it had been swallowed in a solid mass at first. For this reason I think it is advisable, in administering cod-liver oil, to give it an hour or so after, instead of immediately after, a meal, because it will then have a shorter time to stay in the stomach, and will pass out quickly into the duodenum. I think it is better to give cod-liver oil in the form of an emulsion, with gum acacia, rather than with solution of potash or carbonate of potash, because the gum is little, if at all, affected by the gastric juice, whereas the potash will be neutralised, and its emulsifying properties destroyed, so that the particles of oil can again run together. This emulsion with gum acacia is borne by many persons who cannot take pure cod-liver oil, and with whom the potash emulsion also disagrees. Besides the differences in the digestibility of fat due to the mechanical condition of aggregation or subdivision, there are differences also which are due to their chemical composition. Thus, mutton fat is difficult of digestion, while pork fat is easily digested. Butter, too, can be readily taken, and is greatly enjoyed by some persons who cannot take other sorts of fat; and cod-liver oil is usually very well borne, and very easily assimilated. Many opinions have been advanced regarding this ready digestibility of cod-liver oil, and some have sought for its cause in the fact that this oil contains propylene in combination with fatty acids instead of glycerine, like most other fats. Others, again, have attributed it to the minute quantities of iodine, and others to the biliary matters which are found in the oil. The last seems by far the most reasonable supposition. For it has been shown by Neumann that oil of any sort will pass much more readily through a filter, or through an animal membrane moistened with bile, than through one moistened with water. This is still further borne out by the fact which the late Dr. Hughes Bennett used to mention in his lectures, and which has recently been confirmed by the observations of my friend Dr. Russell, that the coarser kinds of cod-liver oil, though more disgusting to the taste, are sometimes more easily

digested than the so-called better qualities. These coarse oils are obtained from livers which have been longer exposed to heat, and contain more of the biliary substances. But it is not improbable that the peculiarity in the chemical composition of the oil which I just now mentioned, may have also something to do with its digestibility and utility. The remark of the old nurse quoted by Weir Mitchell, that cod-liver oil fat was soon squandered, seems to point to the greater mobility, if we may so term it, of the cod-liver oil than of other fats, so that it is both more readily laid on and more readily reabsorbed from the tissues than other fats. Perhaps it is to this greater mobility that the beneficial effects of cod-liver oil, as compared with those obtained from the use of other fats, such as butter, are to be ascribed. In a former part of this paper I observed that the quantity of fat circulating in the blood could be greatly increased by food. Now it may not matter very much to tissues of tolerable permanency, such as the subcutaneous fat, what the fatty substances in the blood may be, as time is allowed for these substances to undergo any necessary modifications before they become deposited in the permanent adipose cells. But the case may be different with mobile tissues, such as the colourless blood corpuscles, which are going to form pus, or with the rapidly developing young cells which help to compose the muco-purulent expectoration in bronchitis. For these it may be a matter of great importance that the fat should be easy of assimilation, the time allowed for such assimilation before the cells are thrown off being very limited.

Some time ago I went to a lecture on sick-room cookery. The lecturer described and demonstrated the different methods of preparing gruel, and observed that whenever the gruel was required for a case of bronchitis, a piece of butter should always be added to it, "because," said she, rubbing her chest with her hand, "butter is so very healing to the inside." She was evidently under the impression that the piece of butter got into the chest, ran all about, and thoroughly greased the air-passages. Her notions of physiology were very confused, but I think her practical observation was perfectly correct. It appears to me that in bronchitis, both acute and chronic, a little cod-liver oil is generally much more serviceable than cough mixtures, and patients express themselves very grateful for the relief which it affords by lessening the cough. Indeed, in many cases of chronic bronchitis, it seems to me to be almost the only remedy which affords any marked relief. The use of this

oil in phthisis is now so universal that I need say nothing about it, but I will pass on to consider the use of fats as a nervous food. I have read that a well-known barrister always swallowed a large dose of cod-liver oil before going to plead a case, because it enabled him to do better mental work than anything else he could take. I myself, after a trial of various things, have come to the conclusion that fat bacon is one of the most satisfactory things upon which to do hard mental work, and I invariably take it for breakfast whenever I have first to see a number of patients and afterwards to deliver a lecture. We have already seen that the nervous system contains a very large proportion of fat, and we can well imagine that if fat be deficient from the food, that system must necessarily suffer; and more especially is this likely to be the case if, in addition to the deficiency of fat, we have an excess of the products of nitrogenous waste, such as we get from an almost exclusively animal diet. A distinguished physician has made the observation that the prevalence of Bantingism has thrown a great number of nervous cases into the doctor's hands, and a friend lately narrated to me the case of a relative of his own who used to suffer from undefined nervous symptoms. Sometimes he sat and moped about all day, simply because he felt that he could not go out alone, and that he was unable to do anything. He would sometimes start for a walk, and after proceeding a short distance, would turn back again. He lived to a great extent on animal food, and, notwithstanding this disinclination to go out alone, he took a great deal of exercise, both hunting and shooting, so that his symptoms were neither due to want of food nor lack of exercise. Some time afterwards he went to Ireland, and whilst there lived on very fat meat and whisky. All the time he did this he felt perfectly well, but whenever he came back and resumed his animal diet, the symptoms returned.

In persons of a gouty temperament, living to a great extent on animal food, especially when they reach middle age, we not unfrequently observe sugar in the urine. It is, I think, a mistake to term this diabetes; it should rather be called gouty glycosuria. The cause of it appears to be that the oxidation in the body is insufficient to consume all the substances taken in as food, and one or other of them must needs undergo imperfect combustion. Accordingly we find that it is sometimes the nitrogenous products of waste which pass out in a state of imperfect oxidation, large quantities of uric acid and urates appearing in the urine instead of

urea. At other times it is the non-nitrogenous products, such as sugar and fat, which escape oxidation, the uric acid being absent from the urine whilst sugar appears, or both uric acid and sugar may be wanting, and fat is accumulated. These processes of imperfect oxidation seem to be very closely connected indeed, for Seegen has noticed, in his work on diabetes, that the disease is often preceded or accompanied by an immense accumulation of fat, so that one patient, who went to be under his treatment at Carlsbad, had actually to be conveyed in a luggage van instead of an ordinary railway carriage. We also notice very frequently that the gouty glycosuria of middle age occurs in stout persons. The same deficiency in oxidation which leads to the accumulation of fat in the subcutaneous cellular tissues, or about the viscera, may also lead to fatty degeneration of organs. The pathology of fatty degeneration has been exceedingly carefully worked out by Voit and Bauer, and the method they adopted was to study the changes which took place in animals during phosphorous poisoning. It is well known that after poisoning by phosphorus the organs of animals are found to be in a state of intense fatty degeneration, and the question which Voit and Bauer tried to solve was, "Whence did this fat come?" It might, they said, have come from the food, or it might have been absorbed from the subcutaneous cellular tissue and deposited, for example, in the liver, or it might have been formed in the liver and other organs from the albuminous constituents of these organs themselves. They solved the question in the following way:—they starved a dog until all its fat had completely disappeared, and then poisoned it with phosphorus. At its death its organs were found to be in a state of exquisite fatty degeneration. The fat here could not have come from the food, for the animal got none; it could not have been absorbed from the subcutaneous cellular tissue and deposited in the liver, for all the subcutaneous fat had gone before the phosphorus was administered. It must therefore have been formed *in situ*, from the albuminous constituents of the organs themselves. So much being ascertained, they had next to discover whether the fat was due to increased tissue change, or diminished oxidation. The albuminous constituents of the organs, they considered, were split up into some nitrogenous substance, and into fat. Normally, both of these undergo oxidation, the nitrogenous substances into urea, and the fat into carbonic acid and water, the splitting up of the tissue and the oxidation going on nearly *pari passu*. If the tissues

split up too rapidly for the products of their decomposition to be oxidised, it is obvious that we shall either have the fat accumulating, or the nitrogenous products imperfectly oxidised, as, for instance, in the case of fever, or of gouty glycosuria. If the amount of oxygen received by the tissues be diminished below the normal, a similar result will occur. In phosphorous poisoning both of these were observed, for the urea was greatly increased, showing that the nitrogenous tissues were split up more rapidly than usual, while the amount of carbonic acid exhaled was diminished, showing that the combustion going on in the body was less than usual. The combustion of the tissues is kept up by the oxygen carried to them from the lungs by the red blood-corpuscles, and whenever the supply of oxygen to the tissues is diminished, either by impoverishing the blood of these corpuscles, or by lessening the flow of blood through the part, accumulation of fat or fatty degeneration is likely to ensue. This fatty accumulation from insufficient oxidation may sometimes be observed in women after severe flooding, the patient becoming exceedingly anæmic, and at the same time very fat. The fatty degeneration due to insufficient oxidation is seen in the muscles of a paralysed limb, where want of exercise has nearly stopped the flow of blood, or in the heart, where the coronary arteries have been rendered too small for the normal heart by calcareous degeneration, or where the hypertrophied heart has grown too big for these arteries to supply it. This fatty degeneration of the heart is frequently met with in persons of a gouty habit, tending to become fat, and at the same time suffering from bronchitis, sometimes complicated by emphysema. In treating such persons the question arises, "Does a fatty condition of the heart, and the tendency to accumulate fat under the skin contraindicate the use of the cod-liver oil which might be beneficial to the bronchitis?" For my own part I am inclined to say no. It is quite true that the oil, after being absorbed, will very probably undergo oxidation more readily than the fat which has been forming in the tissues, but it may be nevertheless beneficial by supplying the wants, not merely of the young cells in the bronchial tubes, which form the expectoration, but by supplying the wants of the nervous centres. In such cases I sometimes give cod-liver oil, notwithstanding the fatty condition of the heart, and trust to increase the oxidation by administering iron so as to increase the number of the red-blood corpuscles, at the same time trying to

eliminate some of the waste materials by keeping the bowels freely open.

If I were to pursue this subject into all its ramifications, I should take up more time than could be allotted to several papers such as this; and therefore in the present one I have merely attempted a slight sketch of some of the more prominent uses of fat, and tried to give a few hints derived from physiological observation, and confirmed, I feel certain, by the experience of many medical men regarding the method of administering fats, and the diseases in which fat is chiefly serviceable.

THE PHYSIOLOGICAL ACTION OF ALCOHOL.[1]

(' *The Practitioner,*' VOL. XVI., *Jany. and Feb.* 1876.)

Is alcohol a food or a poison? Is it one of the greatest boons ever given to mankind, or one of the greatest curses wherewith they are afflicted? These are questions to which we will receive different answers, according to the circumstances under which they are asked. If we ask the man who has just watched by the bedside of his dearest relation during the crisis of a fever, and seen the parched tongue grow moister, the delirium lessen, the quivering pulse grow stronger and steadier under the influence of alcohol, he will probably tell us that if not a food of the same kind as bread and beef, it is, under certain circumstances, better than either, and a blessing whose greatness can hardly be over-estimated. If, on the other hand, we address ourselves to the squalid wife of a drunken husband, who, instead of employing his time in work, and properly spending his evenings, lies in a state of idleness and incapacity for one half the week, and spends the greater part of the wages he receives for the other half in brutalising himself at a gin-palace, we shall probably hear that it is the greatest curse upon earth, a poison destroying soul and body; and she will tell us that but for it she would be a happy woman, instead of a trembling slave living in constant fear of blows or death, her husband would be a respected member of society instead of a brutal coward, and her home would be a Paradise instead of a Pandemonium.

If we inquire why people drink it at all, the answers we receive are no less contradictory. The negro sweltering under a tropical sun drinks it to cool himself; the London cabman shivering at his stand on a wintry morning drinks it to warm himself; the weary traveller drinks it to strengthen his flagging muscles, and help him onwards to his destination; the literary man drinks it to give

[1] Read in part before the Medical Society of London.

subtlety to his intellect, or brilliancy to his wit; the overworked man of business drinks it to rouse him from his apathy, and give sharpness to his bargains; the gamester quivering with excitement drinks it to steady his trembling hand; and the man or woman broken down by misfortune, and weary of life, drinks it to drown care in temporary oblivion.

Irreconcilable as these answers to our questions may seem, we nevertheless know that they are all more or less true; and, in studying the physiological action of alcohol, our endeavour must be to discover how it is that one drug can produce such opposite effects. This is undoubtedly a difficult task, and one which we cannot at present hope to accomplish perfectly. All that we can do is to take the facts we find and arrange them to the best of our ability, trusting to future research for information on those points of which we are now ignorant. In doing this we must bear in mind that alcohol has a threefold action. 1st. Its local action on the skin or mucous membrane with which it comes in contact. 2nd. Its reflex action on other organs, through the sensory nerves of the skin or mucous membranes. 3rd. Its action on the brain, spinal cord, and other organs to which it is conveyed by the blood.

The action of alcohol is modified, too, by the degree of concentration in which it is employed, and by the admixture with it of other substances, such as ethers of various kinds, hops, vegetable acids, &c. Thus, if we moisten the skin with pure alcohol, in the form of eau de Cologne, or diluted with its own bulk of water, as brandy, and allow it to dry spontaneously, a decided sensation of cold will be produced; but if we employ it in a still more diluted form, as wine or beer, the cold will be much diminished, or become quite imperceptible. This cooling action is due simply to the volatility of alcohol, which during its evaporation abstracts heat from the skin and cools it down. If pure it evaporates quickly and produces much cold, but if mixed with much water the evaporation of the mixture is too slow to produce any marked result. Any other volatile substance would have a similar effect, although its other actions upon the body might be utterly different from those of alcohol.

And, indeed, we get a very different result from alcohol itself, if, instead of allowing it to evaporate spontaneously, we prevent evaporation altogether by covering the moistened skin with gutta percha tissue. Instead of coolness we get a burning feeling, most intense if we use pure alcohol, or eau de Cologne, less with wine

and imperceptible with beer. We have got rid of the action which alcohol owes to its volatility, and we have brought into play another which it owes to its chemical properties. So long as it could evaporate readily it acted almost entirely on the epidermis, but when evaporation is prevented it soaks through the epithelium and acts on the vascular tissues beneath. This is better seen if, instead of applying the alcohol to the skin, where the epidermis presents a considerable resistance to its passage, we put it into the mouth, where the thinner epithelium offers less obstruction. Almost immediately after its introduction we experience a burning sensation, which increases for a little while, and then gradually diminishes. If we keep it in the mouth long enough, we notice that the mucous membrane changes its character, and becomes whiter, more opaque, and somewhat corrugated. Although the burning feeling appears to be accompanied by an increased flow of blood to the part, and its disappearance by a diminished flow, yet it is not due to the warmth of the blood, for water at a temperature much above that of the blood produces no such feeling in the mouth. Both the sensation of burning, and the visible alteration in the mucous membrane, are due to the action of the alcohol upon the tissues, and we shall better comprehend the nature of this if we compare it with that of other substances. A piece of hot metal, or a solution of corrosive sublimate, will also cause a burning feeling, and an alteration in the mucous membrane, but, instead of being transitory, it will be more or less permanent. Now there is one point in which they all agree, viz. they all coagulate albumen; and the whitened appearance of the mucous membrane of the mouth after brandy has been long applied to it, is no doubt due to the precipitated albumen on the surface obscuring the red colour which the circulating blood imparts to the tissues beneath. But there is this great difference between the action of alcohol and that of heat, or of corrosive sublimate. The latter produce permanent coagulation while the coagulum formed by alcohol readily dissolves again in water, or in the liquids of the body.[1] Thus its action is more transient; and, if it is only allowed to act for a short time, its effect is counteracted by the blood which dissolves the albumen as fast as it is coagulated, so that we do not see any opacity of the mucous

[1] The coagulation of albuminous fluids by alcohol seems due in the first instance to the simple abstraction of water, and when this is again added, they re-dissolve. If the alcohol acts for a long time upon them, however, their constitution seems to undergo a change, and they become insoluble in water.

membrane of the mouth, unless alcohol has been acting on it for a good while. When frequently applied to the skin, and allowed to evaporate, it seems to act on the epithelium and harden it, and thus it is frequently used to prevent the formation of bedsores and cracked nipples.

Most substances which possess the power of coagulating albumen, such as tannin, catechu, kino, logwood, sulphate of copper, sulphate of zinc, &c., act as astringents when taken internally, and even corrosive sublimate, although not usually reckoned among their number, is strongly recommended in some forms of diarrhœa by Professor Sydney Ringer. Alcohol is no exception to the rule, and we all know that a person suffering from an attack of diarrhœa usually flies to the brandy-bottle for relief before he thinks of consulting a medical man. We know too little about the action of astringents to say positively that alcohol owes its efficacy in this respect to its power of coagulating albumen, but we certainly can say that this properly appears to be the only one it possesses in common with catechu and kino.

The simple experiment of putting a little brandy in the mouth is instructive not only by showing us the local changes which alcohol produces in the mucous membrane, but by reminding us of the second kind of action which alcohol exerts, viz. reflexly through the nervous system. At the same time that the burning is felt, the saliva begins to flow copiously into the mouth. The alcohol has not come in contact with the salivary glands at all, but through the sensory nerves of the mouth it has acted on the nervous centres, and through them upon the vessels and secreting cells of the gland. If we swallow the brandy instead of ejecting it, the feeling of warmth which we experience along the course of the œsophagus and in the stomach itself, informs us that it acts on the mucous membrane of these organs in the same way as on that of the mouth. So far as I am aware, we are at present ignorant of the reflex actions which alcohol exerts through the mucous membrane of the œsophagus, but those which it produces through the stomach are of great importance. First of all come those which concern the secretions and movements of the stomach itself. When the stomach is empty its mucous membrane as seen through a gastric fistula is pale and only covered with a little mucus. If a little alcohol is now introduced the blood-vessels of the mucous membrane dilate and it becomes of a rosy red colour, its glands begin to secrete copiously, beads of gastric juice stand upon its

surface, become larger and larger until they can no longer preserve their form, when they coalesce and run down together in a little stream.

Now every slight stimulation of the stomach seems to be felt as appetite, and thus we find that substances having the most diverse properties induce a desire for food. Alcohol does this in a marked degree, and a nip of brandy is very frequently taken as an appetizer. But appetite seems really to be only an expression of slight uneasiness on the part of the stomach. It cannot distinguish sensations like the mouth, and alcohol which on the tongue causes burning, quassia which causes bitterness, and minute doses of arsenic or tartar emetic which would cause congestion if they stayed in the mouth as they do in the stomach, all cause appetite. Perhaps they do this only by exciting a certain amount of congestion in it, for food itself causes the vessels of the mucous membrane to dilate and its glands to secrete in the same way as we have described after the injection of alcohol, and we all know that a person who begins a meal with no appetite at all often eats with zest after the first bite, and finishes with astonishment at the amount he has consumed. But if the irritation is too strong the whole condition becomes changed.[1] The mucous membrane loses its rosy hue and becomes pale, the secretion of gastric juice ceases while that of a slimy mucus is increased, appetite disappears and is replaced by nausea, and finally vomiting occurs. This change is often clearly seen in a so-called bilious attack, where the irritation of the stomach first manifests itself as an abnormal craving for food, which gives place as the irritation increases to nausea and vomiting.

Now the amount of irritation necessary to produce these totally different conditions of increased secretion with appetite and diminished secretion with nausea varies in different stomachs, and in the same stomach under different conditions. If the stomach is sensitive an irritation will cause nausea, which would only produce appetite if it were less irritable, and *vice versâ*, a sluggish stomach will be benefited by an amount of irritation which one normally sensitive could not bear. Thus we know that in some cases articles of food, such as lobster, which in normal stomachs frequently cause indigestion and nausea, are readily digested while ordinary food is not digested. The stimulus which an ordinary diet gives to the stomach seems here to be

[1] Bernard, *Archive d'Anat. Gén. et de Physiologie*, Jan. 1846, quoted by Power in Carpenter's *Physiology*.—Ed. p. 149.

insufficient to excite the secretion of gastric juice, while the more irritating substances do so and are digested instead of causing over-irritation and vomiting as in the normal condition. But if this explanation be correct, how is it that we take a glass of spirits with our lobster "to digest it"? Is not this adding fuel to fire and increasing the irritating effect of the lobster on the stomach by that of the alcohol? By no means—the fibres of lobster are probably in themselves no more irritating than fibres of beef, but only less soluble in gastric juice, so that they retain their form and hardness instead of being reduced to a pulp, and by thus exerting for a longer time a mechanical irritating action upon the stomach they produce nausea and indigestion, not immediately after they have been swallowed, but in the course of some hours. If, however, an increased secretion of gastric juice be produced by means of a glass of spirits swallowed at the same time with the lobster, we may expect that digestion will take place more rapidly, the fibres will be dissolved, and the prolonged irritation of the stomach being avoided no nausea will ensue.

If insufficient stimulation of the stomach then does not induce a flow of gastric juice, and if excessive stimulation causes nausea, under what circumstances is alcohol likely to be useful? Healthy stomachs with ordinary food do not require it, although in small quantities it may do little harm, and as an adjunct to lobster may be positively beneficial. A large quantity however is certain to be injurious. Moreover, if regularly used, even in small quantities, the stomach may become habituated to it, and refuse to respond to the stimulus of food alone, unless supplemented by that of alcohol. The case is different when we have to deal with a stomach whose sensibility is below par, either permanently or temporarily. In patients convalescent from an acute illness, or weak delicate anæmic persons, the food does not sufficiently stimulate the weakened stomach, the secretion of gastric juice is small, and the meal lies for a long time like a weight at the epigastrium. The same is the case with the merchant, the lawyer, or the doctor, who comes home from his counting-house, his office, or his rounds, and sinks exhausted into his easy-chair, weary and worn out by a long day's work. In such cases the diminished sensibility of the stomach must be compensated by an extra stimulus, and the glass of sherry which to a healthy person not exhausted by over-fatigue would be superfluous, will in them restore the normal equilibrium and quicken the otherwise slow and imperfect digestion.

I do not mean to discuss the wisdom of these men's conduct in thus exhausting their energies, or the question how long such a course can be pursued without ending in an utter breakdown, for it is in many instances sheer necessity which drives them to it, and no remonstrance or warning is of any use. But I would say a word about the amount of stimulants to be employed and the probable effect of excess on the stomach itself. Not only does the sensibility of the mucous membrane become blunted so that it no longer secretes gastric juice in proper quantities when stimulated by food alone, but it secretes mucus in large quantities, and this not only impedes digestion, but facilitates fermentation, by which various injurious substances are formed. Amongst these may be mentioned butyric acid, which causes an acrid burning sensation in the stomach itself, and may, according to Otto Weber and Senator, be absorbed into the blood and there act as a nerve poison, still farther reducing the business capacities of the unfortunate patient, which may already have been sadly diminished by over-work and inability to assimilate proper nourishment.

While then it may be very beneficial to take a moderate quantity of alcohol with meals, an excessive amount will be injurious to the stomach itself, not to mention its action on the nervous system.

In connection with this power of the stomach to adapt itself to the stimulus it ordinarily receives, I may mention that in one part of the Austrian empire the peasantry live almost exclusively on a mixture of oatmeal and water which is allowed to ferment and become sour. Although this diet would in all probability so irritate the alimentary canal of any ordinary person as to produce vomiting and diarrhœa, these people thrive upon it and are very strong and healthy. When the young men however enter the Emperor's army, and come to Vienna, where they get well-cooked food, they nearly all suffer from indigestion, lose flesh, and become weak and ailing—exactly the contrary of what one would have expected. Of course various explanations may be given of this fact, but I am inclined to believe that the indigestion is due to the well-cooked food being less irritating than the sour meal, and not sufficiently stimulating to the stomach and intestines accustomed to the other.

Alcohol taken into the stomach increases the movements of the organ as well as its secretion, and by mixing its contents more thoroughly with the gastric juice accelerates digestion. At the

same time it causes the expulsion of gases, and a little brandy is one of the carminatives most commonly employed by those who suffer from flatulence. But in this respect also the stomach after a little while becomes accustomed to the stimulus, and those habituated to the excessive use of alcohol not only suffer from flatulence due to the processes of fermentation already mentioned, but are less readily relieved by the usual remedies.[1]

We now come to consider the effects which alcohol produces reflexly on other organs through the nerves of the stomach before it has actually been absorbed. The glow which is felt in the stomach after taking a glass of brandy diffuses itself so rapidly over the body that many authorities have considered that it could only do so through the nervous system. Others again believe that absorption takes place so rapidly that the warmth may quite well be, and is, due to the action of the alcohol on the heart and vessels after it has got into them. In this case, as in many others, it is probable that both parties are right, and the effect is due partly to the one cause and partly to the other. For if you wish to warm a man quickly who is shivering with cold you give him a glass of raw brandy, and you do not dilute it with a tumblerful of water. And yet, according to Dogiel,[2] the diluted spirit will be more quickly absorbed than the strong; and if the warming effect is produced by the alcohol only after it gets into the vessels the dilute spirit should act more quickly than the neat. The fact seems to be that the brandy at first increases the circulation and warms the man by acting reflexly on the heart and vessels through the nerves of the stomach,[3] and that afterwards the alcohol is very quickly absorbed into the blood, and keeps up the primary effect by its special action on the nervous system, and through it upon the circulation.

When a large dose of alcohol is swallowed at once, the person or animal very often falls down immediately in a state of perfect

[1] In reference to congestion of the stomach as a cause of appetite *vide* Beaumont, *Experiments and Observations on the Gastric Juice and Physiology of Digestion*, and Buchheim's *Arzneimittellehre*, p. 42. On the secretion of gastric juice and the effect of alcohol upon it, *vide* Beaumont op. cit., Bernard *Physiologie Expérimentale*, vol. ii. p. 388, and Kühne, *Physiologische Chemie*, p. 28.

[2] Dogiel, *Pflüger's Archiv.*, vol. viii.

[3] Reflex contraction of the intestinal vessels probably occurs and drives the blood to the surface. Compare the experiments of Hermann and Ganz (*Pflüger's Archiv.*, vol. iii.), and of Meyer and Pribram (*Wiener Akad. Sitzungsber*, July, 1872), where cold drinks and mechanical irritation of the stomach raised the blood pressure, with those of Heidenhain (*Pflüger's Archiv.*, 1871, vol. iv. p. 1 to 119), where a rise in blood-pressure increased the flow of blood through the cutaneous vessels.

unconsciousness, and unless medical assistance be at hand may never awake. Sir Benjamin Brodie, who made several experiments on this point, attributed this condition to reflex action from the stomach upon the heart and vessels.[1] The irritation applied to the inside of the viscus by the alcohol had produced shock in very much the same way as a blow on the epigastrium would have done.[2] But when alcohol is injected into the veins the animals fall into

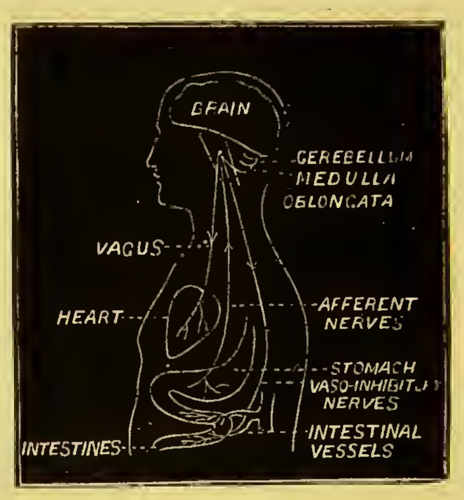

Fig. 16.—Diagram showing the reflex action on the heart and vessels of *large* doses of alcohol introduced into the stomach. The irritation produced by it is conveyed by the different nerves to the medulla oblongata, and thence by the vagus to the head, which it either slows or stops entirely. The mode of action on the intestinal vessels is not certain. It may simply arrest the normal action of the vaso-motor centre upon the intestinal vessels, or may be conducted down to them by vaso-inhibitory nerves, as represented in the diagram. In either case it will cause them to dilate.

much the same condition as when it is introduced into the stomach, and therefore several authorities have thought that Brodie's conclusions were wrong. They are, however, in great measure correct, for he found that a somewhat small dose of alcohol injected into the stomach of a cat knocked it down senseless, and in this condition it remained for about eight minutes. Then it recovered and walked about. There was no time here for the elimination or for the destruction of alcohol in the system, and consequently this effect which passed off so rapidly could not be due to the presence of the drug in the blood, and must be attributed to its action upon

[1] Brodie, *Philos. Trans.*, vol. ci. p. 179.

[2] *Vide* the author's article on "The Pathology of Shock and Syncope," *Practitioner*, vol. xi. p. 243.

the stomach before absorption. But when larger quantities were given the animal did not recover in this short time. Then the primary shock lasted so long that before it passed off absorption had time to take place, the alcohol having found its way into the blood was carried by it to the nervous centres, acted upon them, and the shock passed into alcoholic coma.

While large doses thus paralyze the heart more or less completely, moderate doses stimulate it to act with increased rapidity, and at the same time with increased force. I consider this

Fig. 17.—Diagram showing the reflex action upon the heart and vessels of *moderate* doses of alcohol. The irritation is conveyed to the medulla, as in Fig. 12, but instead of calling into action the vagus and vaso-inhibitory nerves, it excites the accelerating nerves of the heart, and probably the vaso-motor nerves of the intestines, thus increasing instead of diminishing the circulation in the body generally. This difference in the reflex action of large and small doses of alcohol upon the heart and vessels corresponds to the different action, already noticed, of slight and great irritation of the stomach, mechanical or otherwise—the slight stimulation increasing, and the great diminishing or arresting the circulation and secretion.

stimulating action upon the heart through the nerves of the stomach, even when no absorption has taken place, to be one of the most important properties of alcohol, for I believe it is reflexly in this way that we restore the circulation where it has nearly ceased by pouring a glass of brandy down a man's throat. When a person has been nearly drowned, or is dying from exposure to cold—when the pulse at the radial has ceased and the cardiac pulsations can hardly be perceived—we cannot imagine that absorption will go on very quickly from the stomach, and yet the good effects of the spirits we give quickly become evident.

Having said so much regarding the local action of alcohol on the stomach and its reflex action upon the heart through the nervous system, let us consider the effects it produces after its absorption into the blood. It must be constantly borne in mind that these effects are independent of those which alcohol produces reflexly, and may be antagonistic to them; so that after alcohol has acted on the nerve-centres, it may prevent any farther reflex from the stomach.

Most authorities agree in saying that absorption takes place by the veins and not by the lacteals, but some consider it to occur chiefly in the stomach, others in the intestine. In all probability it occurs in both, and slight differences in the fulness of the stomach may alter the proportion taken up by it and by the intestine respectively. Strong alcohol injected directly into the blood causes coagulation, but this of course cannot occur when it is absorbed from the stomach. For if by any possibility it should enter the absorbing venous radicles in a concentrated state the coagulation it would there induce would at once bar its further progress.

It is therefore only with the action of more or less diluted alcohol on the blood and vessels with which we have to do. It acts on the white blood corpuscles by at first increasing and then diminishing their amœboid movements. What the effect of its action on the movements of the white corpuscles will be upon the body as a whole it is difficult to say, but the result of its action on the red corpuscles is more easy to trace. George Harley[1] and Schmiedeberg have found that it lessens their power of giving off oxygen, and must consequently more or less diminish the oxidation of the tissues. Now, both the functional activity of organs and the production of heat in the body depend on the process of oxidation within them, and it is obvious that any interference with these processes is not likely to be beneficial so long as they are going on in a healthy way, and not too rapidly. As we shall afterwards see, however, this effect is to some extent counteracted, or even more than counteracted, by the action of alcohol in accelerating the circulation, and if the quantity taken be small, and not frequently repeated, little or no harm will ensue. If it be frequently taken, however, by persons in average health, and with fair digestion, its effects will become manifest in the imperfect combustion of fat, and its consequent accumulation in the tissues. This seems to occur especially in the skin, which acquires a velvety feeling.

[1] *Proceedings of the Royal Society*, vol. xiii. 1864.

From this quality of the skin I have seen Professor Neumann of Vienna diagnose the potatory habits of a man whom one would otherwise never have suspected. If much saccharine or other fat-forming matters be taken at the same time with frequent doses of alcohol the subcutaneous tissue also becomes loaded with fat, as we so frequently see in brewers' draymen, and if the consumption of alcohol be excessive it causes fatty degeneration of various organs. This power of alcohol to lessen oxidation, useless or even injurious in health, increases the value which its other properties give it in the treatment of febrile diseases, where oxidation is going on too quickly, and rapidly destroying the tissues. The very increase of temperature which this oxidation causes helps of itself to accelerate the disintegration of the tissues, for a high temperature causes them to split up, even although they do not undergo oxidation. Thus the albuminous tissues probably become decomposed and yield urea, other nitrogenous substances, and fat. The fat does not undergo complete combustion but accumulates in the tissues from which it has been formed, and thus the heart of patients who have died of pyrexial diseases, instead of being purely muscular, is generally to a great extent fatty.

In such a condition of pyrexia alcohol will diminish the excessive waste in two ways. Firstly, it will impede oxidation, and secondly, by thus lessening the temperature, it will diminish tissue-disintegration.

But while alcohol thus modifies the blood, does it undergo no change itself? Does it simply course through the vessels for some time until it can be eliminated unchanged by the various emunctories, or does it undergo combustion in the blood as the grape sugar from which it is derived would do, and thus deserve like it the title of food?

Great numbers of experiments have been made to decide this question, and diametrically opposite opinions have been founded on them. Liebig classed it as a food along with sugar and starch, and no doubt was thrown on the correctness of this classification, until Lallemand, Perrin, and Duroy published their experiments, from which they concluded that alcohol is entirely eliminated in an unchanged condition, and can therefore in no sense be termed a food. Their conclusions, however, were much more general than their experiments warranted, and they did not pass unchallenged. What their research actually showed was not that the whole of the

alcohol injected passed out of the body, but only that a part of it is excreted. Similar experiments were made by Baudot, who instead of using large doses used small ones, and he found that instead of the whole or a great part of the alcohol being excreted, only a small fraction, so small as to amount practically to nothing, found its way out through the kidneys. The question was then taken up by the late Dr. Anstie, who did much to solve it; and had he only lived to complete the researches on which he was engaged at the time of his death would have settled it completely. His experiments, as well as those of Thudichum, Dupré, and Schulinus, confirm Baudot's, and show that only a trifling fraction is eliminated. A year or two ago, Subbotin published some experiments, in which he found a much larger proportion of the alcohol to be excreted than the other observers just mentioned had done, but he, as well as Lallemand, Perrin, and Duroy, used very large doses. Now we all know that grape sugar is a most valuable food—the food we may say *par excellence* of the body, for others are converted into it in the liver—and in moderate quantities it undergoes complete combustion in the body, and is not eliminated in the urine. But a man may be rendered temporarily diabetic by giving him a large quantity of syrup at once, for the organism not being able to consume more than a limited amount at a time, the excess is thrown out by the kidneys. It is therefore not to be wondered at that alcohol should be excreted after large doses have been taken; in fact, the wonder would be if it were not.

The importance of the question whether alcohol undergoes oxidation in the body or not consists in this; if it is oxidized it will supply energy for muscular exertion, or for keeping up the animal heat, or for both, and will therefore be entitled to rank as a food, while if it is excreted unchanged it will have no claim to the name, and must be classed with such substances as the organic alkaloids, which after acting on the nervous and muscular systems, while they are circulating in the blood, pass out after a while by the emunctories. It is the merit of Baudot, Anstie, and others who have worked at this subject, to have shown that alcohol is oxidized, and is thus to be reckoned as a food and not merely as a drug. But still more satisfactory evidence of its claim to the title of food is afforded by the fact that it will keep up the weight of the body and prolong life when the supply of other food is insufficient or is entirely wanting.

Dr. Hammond found that when he took an insufficient diet and

was daily losing weight, the addition of alcohol not only prevented this loss of weight, but converted it into an actual gain.[1] In his work on "Stimulants and Narcotics," Dr. Anstie has collected a number of cases in which persons have lived for a considerable time either upon it alone or along with a quantity of food so small as to have been utterly inadequate without it.

From a survey of all the evidence on this subject, I think we may conclude that in moderate doses alcohol undergoes combustion in the body, and will supply energy, yield warmth, and tend to sustain life in the same way that sugar would do, and is therefore to be reckoned as a food. At the same time it has a power of diminishing oxidation which prevents its employment as a food to any great extent in health, but greatly increases its utility in disease.

In feverish conditions it diminishes tissue waste, and thus keeps up strength in three ways:—1. It undergoes combustion itself as a food instead of the tissues. 2. It lessens oxidation in them. 3. It lowers the temperature which itself increases tissue degeneration. It may perhaps seem rather contradictory to say that it undergoes combustion and yet diminishes combustion, but in this respect we may compare it to the sulphur which some people are accustomed to throw into their grate when the chimney takes fire—the sulphur burns itself, but it puts out the blazing soot.

We now come to the action of alcohol upon the heart and vessels, and in order to prevent any complication from the reflex action of which we have already spoken, let us suppose that instead of pure brandy dilute spirits or some light wine has been taken, which will have little or no irritating effect upon the gastric mucous membrane. One of the best possible opportunities of studying the earlier and slighter effects of alcohol is afforded by a public dinner. If we look at our own hands or those of our neighbours before going in, especially if the ante-room is somewhat cold, we may find them somewhat pinched-looking; the colour somewhat dusky and distributed in patches instead of being uniform; the veins very thin, almost like threads. They are of a somewhat dark blue colour, and on emptying them by pressure they fill very slowly, showing that the circulation is languid. After a few glasses of wine, however, their appearance begins to change. The hands now assume a uniform rosy tint, showing that the capillaries are now dilated and filled with bright arterial instead

[1] Hammond's *Physiological Researches*, p. 55.

of dark venous blood; the veins swell up, become prominent, of a light blue colour almost like arteries, and when emptied by pressure fill rapidly, showing that the circulation has become very quick, and that they, like the capillaries, are now filled with blood which is tolerably bright, if not quite arterial, instead of the dark blood they previously contained. The hands entirely lose their shrunken look, little wrinkles in the skin disappear, indeed the hands become larger than usual, or, as my neighbour at a dinner-table one expressed it, they become "podgy," from the amount of blood and intercellular fluid in the vessels and tissues; and rings previously loose become almost too tight. This dilatation of vessels, so readily seen in the hands, is not confined to them, but occurs generally throughout the body. The warm blood pouring from the interior of the chest and abdomen over the surface imparts to it a pleasing glow, and a most agreeable feeling of comfort pervades the whole frame. The face shares the general flush, and the pulsation of the temporal arteries not unfrequently becomes easily visible. The current of blood throughout the body is more rapid than before, and this rapidity does not depend simply on the dilated vessels offering less resistance to the current of the blood. No! the alcohol has stimulated the accelerating nerves of the heart, which cause it to pulsate not only more rapidly but more powerfully, so that in animals, despite the dilatation of the vessels, the pressure has been found to rise in the arteries.[1] Here we have one at least of the most important conditions for the nutrition of all the tissues. The slight diminution in the oxidizing power of blood which alcohol occasions is many times over compensated by the amplitude of its current, and, as this is flowing rapidly through the tissues, bringing them new food and carrying off their waste products, is it any wonder that they work with more than usual vigour? The muscles acquire new strength; the work which previously fatigued them is done with ease; the mental faculties become much more acute, and new ones, previously unsuspected, may even appear. The merchant will be able to drive a harder bargain, the student will solve the problem which previously baffled him, the man who tries with difficulty to speak in a foreign language finds his stammering disappear and his tongue run on with ease, the melancholy man may sing a merry ditty, and the sedate man, whom no one would ever have suspected of such a thing, may succeed in making an excellent joke.

[1] Dogiel, *Pflüger's Archiv.*, vol. viii. p. 605.

Provided the liquor has been good, or, in other words, provided the alcohol employed has been free from all injurious admixture, all these effects, I believe, may be produced, and may pass away without any bad effects.

In the preceding lines I have sketched the action of alcohol in its fairest aspect, but its effects are not always so pleasant; for not a few persons, instead of becoming more bright, lively, active, and intelligent after taking a little alcohol, become heavy, sleepy, and stupid. These different effects are partly dependent on the different constitution of the individuals, and partly on the quantity and kind of the alcoholic beverage. We find that the same differences exist in the effect of walking exercise upon the mental powers. Exercise, like alcohol, both dilates the vessels and increases the action of the heart. The mental processes of some persons go on very slowly when they are walking, and if they are asked a question they stand still to think and answer it.[1] They can think still better when they sit, and their brains are perhaps yet more active if they lie down. Others, again, do their brain-work more easily when walking about, and so instead of remaining at their desk they pace the room incessantly while thinking, and only take the pen in their hand when they are ready to write. At first sight, it seems odd that the conditions most favourable for thought should be so different in two persons, and yet when we come to examine them more closely we find that both

Fig. 18.—Tracing showing the increased circulation in the brain caused by inclining the head and body forwards. The tracing was taken by Brissaud and François-Franck, from the parietal region of a woman who had lost a large piece of bone from syphilis.—*Marey's Travaux for* 1877, p. 147.

persons, in different ways, are seeking the same thing, viz. a fuller supply of blood to their brains. Position has a good deal to do with this, the head receiving more blood when it is lowered than

[1] It must be remembered that the effects here discussed may be due in great measure to diversion of nervous energy (*vide* the author's article on "Inhibition Central and Peripheral," *West Riding Asylum Reports*, vol. iv. p. 210), and not entirely to altered distribution of blood.

when it is high. Almost every one unconsciously shows this by bending forward instead of sitting upright when engaged in lively conversation, and more especially in debate, when the greatest possible mental activity is desired.[1] The influence of position also makes itself felt, in the kneeling posture—for example, during prayers in church, where sometimes, very much against the will of the individual, thoughts utterly unconnected with the devotions in which he appears to be engaged whirl through his brain, new projects are formed and problems solved with a rapidity surprising to himself. In some persons whose blood-vessels are lax, either from natural constitution or in consequence of debility or exhaustion, the recumbent posture, which allows a free current of blood to the head, is the most favourable for thought.[2] Now both exercise and alcohol have the effect of dilating the vessels, and, at the same time, of increasing the action of the heart. In some persons the relaxation of the blood-vessels caused by exercise is greater than the stimulation of the heart, so that, although this organ is beating somewhat more vigorously, the dilated vessels of the body draw away the blood and leave the brain more anæmic than before. Consequently such persons do not think so well while walking, and they may be rendered rather stupid than lively by alcohol. Others again, in whom stimulation of the heart is more easily induced than relaxation of the vessels, either by exercise or alcohol, so that the rapid and powerful cardiac pulsations increase the current of blood to the brain more than the dilated vessels can diminish it, think well while walking about, and have their mental power increased by alcohol.

A moderate quantity of alcohol may thus enable a man to overcome a sudden difficulty, but can its effects be kept up so as to help him with a prolonged effort? Does the alcohol supply new strength, or does it merely enable a man to use up his reserve of energy? If it really supplies strength we ought to find it doing so each time it is administered; but if it merely helps to use up reserve energy, we will find that each successive time it is given the organism responds less and less readily to the call, just as a man gives more and more grudgingly at each successive demand upon his purse. Now the question was

[1] This statement is well illustrated by the tracing (Fig. 18), which here accompanies it, but which was not published until a year after this paper.

[2] This is, however, often interfered with by some other factor, possibly some reflex action from the skin of the head, which induces sleep in this position.

thoroughly tested during the Ashanti campaign, and the following are the results as recorded by Professor Parkes:[1]—

"The first effect of alcohol, when given in a moderate dose (for example, what is equal to one fluid ounce of absolute alcohol), is reviving, but this effect is transient. The reviving effect goes off after at the utmost two and a half miles of additional march, and sometimes much before this; then the previous languor and sense of exhaustion not only return, but are sometimes more intense, and if alcohol is again resorted to, its effects are now less satisfactory. Its reviving power is usually not so marked, and its peculiar anæsthetic and narcotising influence can often be distinctly traced. The men feel heavy, dull, disinclined to march, and are less willing and cheerful."

From this it is evident that alcohol does not impart strength, but rather enables a man to use up in a short time the energy which he usually would have taken a much longer time to expend. If he only requires to make a single effort and can rest afterwards until he has replaced his exhausted store, the additional temporary strength obtained by using alcohol may enable him to overcome an obstacle which would otherwise have baffled him, but if he has to make prolonged exertions alcohol is injurious.

Now the heart seems to be affected by alcohol in the same way as the body generally. No new strength is imparted to it, but it is enabled to draw on its reserve. Thus Parkes has found that when brandy is given to healthy men the pulse becomes quicker, but after the effects of the brandy have passed off it becomes slower than natural, so that the number of pulsations and amount of work done by the heart in twenty-four hours is much the same whether brandy have been taken or not, unless the doses be large and repeated.[2]

The question therefore at once arises,—Is alcohol only useful in stimulating the heart to do additional work, and thus averting the danger of failing circulation for a short time only, or can it be used in diseases where this danger is to be averted for days, and even weeks, together? Before attempting to answer this question, I would remind you that a heart which is beating more quickly than usual wears itself sooner out than one which is acting slowly. It has been found that a heart which has been made to pulsate slowly for some time by irritation of the vagus, will continue to beat for

[1] *On the Issue of a Spirit-Ration during the Ashanti Campaign of* 1874, p. viii.

[2] Parkes, *Proceedings of the Royal Society*, No. 150, 1874, p. 190.

a good while after it has been removed from an animal's body; while, on the contrary, it very soon ceases to beat if the vagi, instead of being irritated, have been cut, so as to allow the pulsations to be very rapid for some little time before the animal's death.[1] What is observed in these excised hearts is only an exaggerated representation of what occurs in the body, and although in it the pulsations may continue days instead of minutes, yet the final result will be similar. If alcohol always quickened the pulse in disease as it generally does in health it would probably be injurious in prolonged illness, as it was found to be in prolonged exertions by the soldiers in Ashanti. But this is not the case, for in fever the quick pulse frequently becomes slower after the administration of alcohol, and, indeed, an excellent rule of practice is not to give alcohol if it increases the rapidity of the pulse already too quick. Alcohol thus economises the vital power of the heart, and tends to prevent death from exhaustion. It is difficult to say precisely how the slowing of the pulse is effected. Probably it is due partly to stimulation of the vagus, for alcohol stimulates this nerve as well as the accelerating nerves of the heart, and partly to the alcohol increasing the power of the weakened vasomotor centre, either by acting upon it directly or by increasing the supply of blood to it, and thus giving greater tone to the vessels and raising the pressure in them. It may be also partly due to the action of the alcohol in lowering temperature. For heat is a stimulant, and cold is a sedative to the ganglia of the heart both in and out of the body, and other things being equal, its pulsations will be quick or slow according as the temperature is high or low.[2] And just as hearts which have been beating quickly in consequence of division of the vagi, soon lose their vitality, so do hearts which have been pulsating rapidly in consequence of heat, soon cease to beat, while those which have been exposed to a lower temperature and have been beating more slowly, retain their vitality for a considerable time.[3]

The power of alcohol to reduce the animal heat is assisted by its property of diminishing oxidation, but is chiefly, no doubt, due to its action upon the vascular system. As I have already mentioned,

[1] Czermak and Piotrowsky, *Wiener Akad. Sitzungsberichte*, xxv. p. 431.

[2] Panum, *Bibliothek für Lager*, Bd. xi. p. 468, and Schmidt's *Jahrb.* 1858. For other references, and for some original experiments on this subject, see the author's article on "The Influence of Temperature on the Mammalian Heart, and on the Action of the Vagus," *St. Bartholomew's Hospital Reports*, vol. vii.

[3] Panum and others, op. cit.

it produces a rosy flush and a glow on the skin by dilating the cutaneous vessels and allowing the warm blood from the interior of the body to circulate freely through them. This agreeable warmth is popularly believed to be due to increased production of heat in the body, and persons leaving a warm room for a cold walk or drive will often take a glass of spirits "to keep out the cold." But alcohol instead of really heating the body, only warms the skin at the expense of the heart, lungs, and intestines, and so really lets in the cold to these organs from which nature tries hard to exclude it. For, in a healthy man external cold causes all the vessels of the skin to contract, so that very little blood flows through them, or none at all. The skin itself thus becomes cold and blue, but the deeper structures retain their normal warmth, for heat passes from them to the skin very slowly indeed by simple conduction, and it is the circulation which maintains among them an equality of temperature. When alcohol is taken, however, this arrangement is disturbed, the cutaneous vessels instead of contracting become dilated, and the blood pouring through them warms the cold skin comfortably. But in doing this it loses heat itself; it returns to the heart at each revolution a little colder than it left it; soon the temperature of the whole mass of blood and of the internal organs becomes reduced, and the last state of that man is much worse than the first. Where men are subject to great and prolonged exposure to cold, experience has taught them the danger of taking spirits while the exposure continues. My friend Dr. Fayrer told me that when crawling through the wet heather in pursuit of deer on a cold day, he offered the keeper who accompanied him a pull from his flask. The old man declined, saying, "No, thank you, it is *too cold*." The lumberers in Canada who are engaged in felling timber in the pine forests, living there all winter, sleeping in holes dug in the snow, and lying on spruce branches covered with buffalo robes, allow no spirits in their camp, and destroy any that may be found there. The experience of Arctic travellers on this subject is nearly unanimous; and I owe to my friend Dr. Milner Fothergill an anecdote which illustrates it in a very striking way. A party of Americans crossing the Sierra Nevada encamped at a spot above the snow line, and in an exposed situation. Some of them took a good deal of spirits before going to sleep, and they lay down warm and happy; some took a moderate quantity, and they lay down somewhat but not very cold; others took none at all, and they lay down very cold and miserable. Next morning, however, those who

had taken no spirits got up feeling quite well, those who had taken a little got up feeling cold and wretched, those who had taken a good deal did not get up at all, they had perished from cold during the night. Those who took no alcohol kept their heart warm at the expense of their skin, and they remained well; those who took much warmed their skin at the expense of their heart, and they died.

But while alcohol is thus injurious during prolonged exposure to cold, the case is very different after the exposure is over, and its administration may then be very beneficial. Supposing a man after being out all day comes home much chilled to a warm fire-side. He stands before the grate and turns himself round and round, but he cannot get himself warmed through. The cutaneous vessels so long contracted by the cold will not relax all at once, and the deeper tissues gain heat very slowly, just as they lose it very slowly, by mere conduction through the skin. If a little spirits be now taken, and especially if it be taken hot, the cutaneous vessels dilate, allow the blood to circulate through them and become warmed by the fire, it returns warm to the internal organs and soon the whole body is in a pleasing glow. At the same time the dilatation of the cutaneous vessels opens new channels to the blood which has been pent up in the interior of the body, and thus lessens any tendency to congestion or inflammation of internal organs, so that a glass of hot brandy and water at the proper time may possibly prevent a bronchitis or pleurisy. Here I may just mention that although alcohol during continued exposure is generally injurious, yet in some instances where pain or cramp in the internal organs seem to indicate more risk from their engorgement than from diminution of the general temperature of the body, it may be beneficial, even while the exposure continues.

The dilatation of the vessels produced by alcohol has other consequences than equal distribution of heat between the surface and interior, for the dilatation does not occur equally in every vascular district. Generally the vessels of the brain are especially dilated, as is seen both from the mental activity usually manifested, and from direct observation of the vessels themselves; but sometimes those of other parts, probably those of the intestines, would seem to be more particularly affected, and the blood being thus drained away from the brain, it becomes anæmic and sleep ensues.

We have now to consider the effects of alcohol when given in such quantities as to evidence its poisonous qualities and produce

intoxication. Excepting when the dose is so excessive as to produce shock, the symptoms of intoxication are always preceded by those of stimulation already described. It is (as I have already observed) very difficult to say how far the stimulating action depends on the increased circulation through the nervous centres only, or how much of it may be due to the action of the alcohol on the nervous structures themselves. The symptoms of intoxication must, however, be referred to a paralysing action of the alcohol on the nerve centres, for although as intoxication progresses a diminution in the activity of the cerebral circulation occurs, and the well-nourished brain becomes anæmic, this alone is insufficient to acount for the effects we observe. The first of these are weakening of the mental faculties and of the power of co-ordination. The higher faculties seem to go first, and a man's judgment becomes impaired while his memory and imagination are still more lively than usual. Then these faculties diminish and the emotions become more prominent, so that a man is either ready to swear eternal friendship all round, or becomes as anxious for a fight as an Irishman at Donnybrook; is gay, mirthful, and hilarious, or subdued and lachrymose, melting into a flood of tears without any apparent cause.

At the same time that the cerebral faculties are disappearing one after another, the power of co-ordination becomes impaired. This is most evident in the tongue and legs, the speech becoming thick and indistinct, so that the pronunciation of the words "British Constitution" becomes next to an impossibility, and locomotion becomes staggering and uncertain. Although loss of the mental faculties and loss of co-ordination power generally go hand-in-hand, yet either of them may occur a good while before the other, so that persons who seem stupefied by drink may rise and walk with the utmost steadiness, while others who seem perfectly unaffected while sitting and can discourse on any subject with freedom will find great difficulty in steering their way from the table to the door. In popular language, one man is said to be drunk in his head and another in his legs. It is not, however, the legs that are in fault, as the drunk man himself well knows, but the nervous apparatus that directs them, and this in all probability is the cerebellum, as Flourens supposed it to be. This physiologist found that when he sliced away the cerebellum bit by bit the animals walked exactly as if they were drunk,[1] and on the

[1] *Propriétés et Fonctions du Système Nerveux*, p. 327.

other hand, when he examined the cerebellum of drunk animals he always found it to be congested. The researches of my friend Professor Ferrier render it all the more probable that the cerebellum is the nervous centre on which this loss of locomotory power depends, for he has found it to be the centre for regulating the movements of the eyes and co-ordinating the motions of the body with them. Now double vision is one of the most marked symptoms of alcoholic intoxication, and the staggering of a drunk man seems to be dependent on erroneous conceptions of the position of surrounding objects, for he not unfrequently vehemently asserts that he is perfectly steady but everything else is drunk, and all his troubles are owing to an ill-disposed lamp-post which went out of its way to bump him, or an evil-minded pavement which rose up and hit him on the nose.

The cerebrum and cerebellum are thus the first parts of the nervous system to suffer, and even after their functions are completely abolished the spinal cord will perform its functions, and a man incapable of thinking, speaking, or walking, will be able to ride, the impression made on his legs by the saddle causing reflex contraction of his adductors and enabling him to sit tolerably firmly although the upper part of his body may be swaying helplessly about. At this time, however, the reflex action of the nerve centres regulating the heart's vessels is much impaired or almost entirely abolished,[1] and herein is one source of safety to the drunk man. For sometimes a person in this condition may be seen riding furiously along a road, the horse swerves or turns a corner quickly and the rider is pitched forcibly off. The bystanders rush up expecting to find him dead, but no, beyond a severe bruise or two, and perhaps some tear or cut, he is nothing the worse. The fall which would have killed a sober man has not hurt the drunk one, for the alcohol has paralysed the nervous apparatus,[2] through which shock would otherwise have been produced.[3] The medulla oblon-

[1] *Vide* Dogiel, *Pflüger's Arch.* viii. [2] *Practitioner*, vol. xi. p. 250.

[3] Leslie Stephen tells the following anecdote regarding a guide which illustrates this subject:—

"Michel was one day descending from the well-known path which leads from the so-called Eismeer to Grindelwald in an unduly convivial frame of mind. Just above the point where mules are generally left, the path runs close to the edge of an overhanging cliff, the rocks below having been scooped out by the glaciers in old days when the glacier was several hundred feet above its present level. The dangerous place is guarded by a wooden rail, which unluckily terminates before the cliff is quite passed. Michel, guiding himself as it may be supposed by the rail, very naturally stepped over the cliff when the guidance was prematurely withdrawn. I cannot

gata continues its functions after the cord has ceased to act, but by and by it also succumbs; and if the dose be sufficiently large the respiration becomes weaker and weaker, and finally death ensues.

The motor ganglia of the heart are also weakened by the action of alcohol upon them, but, in general, death is due to stoppage of the respiration, and not of the circulation, except in cases where shock has been produced by enormous doses of alcohol swallowed at once.

To resume, the chief points in this paper are:—

1. Alcohol, in small quantities, increases the secretion of gastric juice and the movements of the stomach, and thus aids digestion. Although unnecessary in health, it is useful in exhaustion and debility.

2. It increases the force and frequency of the pulse, by acting reflexly through the nerves of the stomach.

3. In large doses it impairs digestion by over-irritating the stomach.

4. It may produce death reflexly by shock.

5. After absorption into the blood, it lessens the oxidising power of the red blood corpuscles. This property renders it useful in reducing temperature; when constantly or very frequently present in the blood, it causes accumulation of fat, and fatty degeneration of organs.

6. It undergoes combustion in the body, maintains or increases the body weight, and prolongs life on an insufficient diet. It is therefore entitled to be reckoned as a food.

7. If large doses be taken, part of it is excreted unchanged.

8. It dilates the blood-vessels, increases the force and frequency of the heart by its action on the nervous centres to which it is conveyed by the blood, imparts a feeling of comfort, and facilitates bodily and mental labour. It does not give additional strength,

state the vertical height through which he must have fallen on to a bed of hard uncompromising rock. I think, however, that I am within the mark in saying that it cannot have been less than a hundred feet. It would have been a less dangerous experiment to step from the roof of the tallest house in London to the kerbstone below. Michel lay at the bottom all night, and next morning shook himself, got up, and walked home sober, and no broken bones. I submit two morals for the choice of my readers, being quite unable, after much reflection, to decide which is the most appropriate. The first is: Don't get drunk when you have to walk along the edge of an Alpine cliff; the second is, Get drunk if you are likely to fall over an Alpine cliff." *The Playground of Europe*, p. 87.

but merely enables a man to draw upon his reserve energy. It may thus give assistance in a single effort, but not in prolonged exertions.

9. The same is the case with the heart; but in disease alcohol frequently slows instead of quickening the pulsations of this organ, and thus economises instead of expending its reserve energy.

10. By dilating the vessels of the skin, alcohol warms the surface at the expense of the internal organs. It is thus injurious when taken during exposure to cold, but beneficial when taken after the exposure is over, as it tends to prevent congestion of internal organs.

11. The symptoms of intoxication are due to paralysis of the nervous system; the cerebrum and cerebellum being first affected, then the cord, and lastly the medulla oblongata. It is through paralysis of the medulla that alcohol usually causes death.

12. The apparent immunity which drunken men enjoy from the usual effects of serious accidents is due to paralysis of the nervous mechanism, through which shock would be produced in a sober condition.

ON THE PHYSIOLOGY OF VOMITING AND THE ACTION OF ANTI-EMETICS AND EMETICS.

(*'The Practitioner,'* VOL. XIII. p. 409, Dec. 1874.)

THE act of vomiting consists in the forcible expulsion of the contents of the stomach through the œsophagus and mouth. It may seem almost unnecessary to mention the œsophagus at all, for anything passing from the stomach to the mouth must needs do so through the œsophageal tube. And yet this fact is not always borne in mind, and the active share which the œsophagus takes in producing emesis being forgotten, a false conception of the mechanism of vomiting is formed. For a long time opinions were divided regarding the part taken by the stomach in the expulsion of its contents. Some stated that this was chiefly effected by the active contractions of the gastric walls. Others affirmed that the stomach was entirely passive, and was merely emptied by the mechanical pressure exerted upon it by the simultaneous contraction of the diaphragm and abdominal muscles. It has now been shown that the first view is incorrect, and that the movements of the stomach cannot expel its contents[1] except in rare instances.[2] Vomiting consists essentially in the simultaneous contraction of the abdominal muscles and diaphragm, which press on the stomach so as to squeeze out its contents. When these muscles are prevented from acting, either by cutting them across or by paralysing them with woorara, vomiting does not occur, although the stomach may be moving actively.

On the other hand, vomiting may be produced by the contraction of the diaphragm and abdominal muscles, although the stomach

[1] Magendie, *Mémoire sur le vomissement*, p. 23; Gianuzzi, *Centralblatt der med. Wissenschaften*, 1865, p. 3.

[2] Budge, *Die Lehre vom Erbrechen*, p. 34.

remains perfectly quiet, and even when it is replaced by a simple bag. This was shown by the well-known experiment of Magendie.[1]

This physiologist removed the stomach of a dog and attached a pig's bladder filled with fluid to the œsophagus in its place. He then injected tartar emetic into the veins of the animal, and found that vomiting occurred in the same way as if the stomach had been *in situ*. He noticed, too, that vomiting could be produced by the contraction of the diaphragm alone, after the whole of the abdominal muscles had been cut away, the linea alba only being left,[2] and also, though imperfectly, by the contraction of the abdominal muscles alone, after the diaphragm had been rendered nearly motionless by section of the phrenic nerves.[3] In ordinary vomiting, however, the diaphragm and the abdominal muscles co-operate together.

But it is quite evident that in vomiting there is something more than mere pressure of the stomach between the diaphragm and the abdominal muscles. In severe coughing the stomach is squeezed violently, but its contents are not usually expelled. The reason of this is, that in coughing the œsophagus remains firmly contracted, and prevents anything escaping from the stomach. In the act of vomiting, on the contrary, the œsophagus relaxes, and allows the gastric contents to pass freely through it.[4] In vomiting, therefore, there are two factors, viz. (1) pressure on the stomach; (2) a relaxed condition of the œsophagus, especially at its under end, just where it joins the stomach. This under end is sometimes called the cardiac sphincter of the stomach, although there does not appear to be any distinct band of fibres thicker than the rest at this point, as the name would imply.[5]

If either factor be wanting, vomiting will not take place. The relaxation of the sphincter is of no use if the muscles do not contract, and they will exert themselves in vain if the cardiac sphincter remain contracted. This is seen in retching, which sometimes occurs without vomiting, even when the stomach is tolerably full.

The relaxation of the cardiac sphincter is effected by contraction of the longitudinal fibres which run along the under end of the

[1] Magendie, op. cit., p. 19.
[2] *Ibid.* op. cit., p. 23, and Budge, *Die Lehre vom Erbrechen*, p. 43.
[3] *Ibid.* op. cit., p. 21.
[4] Schiff, Moleschott's *Untersuchungen*, Bd. x. p. 378.
[5] Gianuzzi, *Centralblatt der med. Wiss.*, 1865, p. 3.

œsophagus below the diaphragm, and then radiate obliquely over the stomach. When these contract, they draw the cardiac end of the stomach nearer to the diaphragm, and at the same time dilate the cardiac orifice.[1] When they are paralysed, vomiting becomes impossible. If their innervation be disturbed, so that they do not work in concert with the diaphragm and abdominal muscles, vomiting will occur only rarely, or not at all; for in such a case when the abdominal muscles contract, the cardia will probably be closed; and when the cardiac orifice is open, the abdominal muscles will probably not contract.[2] Thus, neither action is of any use, and it is only when, by some accident, they happen together, that vomiting takes place.

It would be difficult for the muscles to exert any great pressure on the stomach if it were nearly or quite empty, but they will do so effectually if it be full. For this purpose it will not matter very much whether it is filled with food or air; and so it seems that both animals and men swallow air before vomiting. The emptier the stomach, the more air do they require in order to distend it, and the oftener do they swallow air. But it is impossible to swallow air alone; saliva must be swallowed at the same time. The ordinary secretion of saliva would probably be insufficient for this purpose, and we generally find that vomiting is preceded by such profuse salivation as will enable many swallowing movements to be made rapidly one after another.

When the stomach is very full, vomiting is somewhat difficult, for the organ then turns forward in such a way as to form a fold at the lower end of the œsophagus, and thus partially prevent the exit of its contents. Vomiting never occurs in the horse or rabbit, and rarely in guinea-pigs. This is probably due to the great length of that part of the œsophagus which lies between the diaphragm and stomach, so that the contraction of the longitudinal fibres causes it to fold and obstruct the cardiac orifice instead of opening it as in other animals.

The phenomena of vomiting may be thus described. Uneasiness is felt; the inspirations become deeper; several swallowing movements are made which sometimes carry down sufficient air to distend the stomach moderately. After several deep inspirations there suddenly comes one which is deeper still. Then, instead of this being followed by expiration, the glottis shuts to prevent the escape of air, the diaphragm contracts still more, thus descending more

[1] Schiff, op. cit., p. 380. [2] *Ibid.* p. 399.

deeply into the abdomen, and pulling the ribs together; the abdominal muscles forcibly contract; the left half of the stomach is drawn upwards,[1] and the cul-de-sac flattened out; the cardiac orifice dilates, and the contents of the stomach are forcibly expelled. The pylorus remains firmly contracted, and allows but little to escape into the intestines. The closure of the pylorus has been ascribed by Budge,[2] partly to mechanical compression by the liver, which is pushed down upon it by the diaphragm, and partly to contraction of its muscular fibres induced by the irritation of the pressure. It seems more probable, however, that the contraction of the pylorus is not due to any local cause, but is regulated, like that of the other muscles, by the nervous centre which presides over the act of vomiting.

This centre is situated in the medulla oblongata, and it is identical with, or closely connected with, the nervous centre which regulates respiration. It is connected with the abdominal muscles, the diaphragm, the stomach, and the œsophagus, by the intercostal, phrenic, and pneumogastric nerves respectively. Along these it sends the motor impulses which make the muscles contract and produce vomiting. For the sake of simplicity these nerves have not been represented in the diagram.

The nervous centre for vomiting is supposed to be closely connected or identical with the respiratory centre in the medulla oblongata. The reasons for this supposition are (1) that the movements of vomiting are excessively great and somewhat modified respiratory movements, and (2) that emetics excite the respiratory centre, while depression of the respiratory activity stops vomiting. Usually it is easy, by vigorous artificial respiration, to saturate an animal's blood with oxygen, and then, having no longer any need of fresh air, it ceases to breathe for a while; and any person after taking a few deep breaths will find that he can hold his breath a much longer time than before. The condition in which no respiration is needed, and consequently no movements of breathing are made by the animal, is termed *apnœa* by the Germans, while we use the same term to signify an aggravated condition of dyspnœa. I use the term in its German sense. If emetics are injected into the veins, the respirations become more frequent; and it is stated by Hermann and Grimm, that no apnœa can be produced by the most vigorous artificial respiration. And

[1] Schiff, op. cit., p. 362.

[2] Budge, *Die Lehre vom Erbrechen*, p. 49.

on the other hand, the artificial respiration prevents the occurrence of vomiting so long as it is continued.[1] This seems to indicate that the respiratory and vomiting centres are closely connected, and it is by no means improbable that some of the nerve cells and fibres which compose the respiratory centre in the medulla oblongata also form part of the centre for vomiting. Yet the movements of respiration and vomiting, although somewhat alike, differ very considerably from each other; and we are, I think, justified in supposing that the centres for respiration and vomiting are not absolutely identical,[2] although a part of each may possibly be common to both. More-

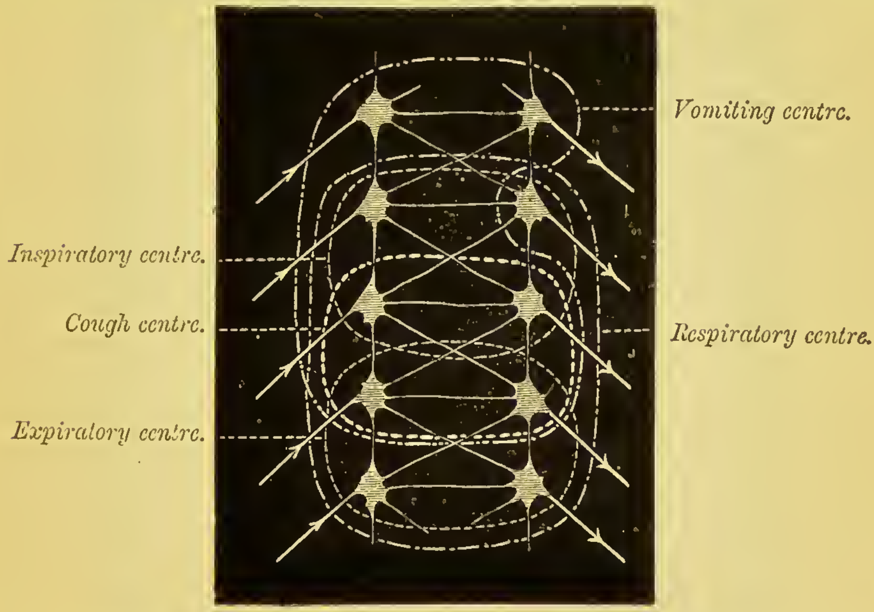

Fig. 19.—Diagrammatic representation of various groups of ganglion cells or "centres" in the medulla oblongata. The arrows indicate the directions in which the nerve-currents pass. Those pointing to the cells indicate sensory nerves, those pointing from the cells indicate motor nerves.

over, the centre for vomiting may be completely paralysed by narcotics, such as opium, chloral, or chloroform, while the respiratory movements continue or may even be increased.[3] I have also found that in chloral narcosis it is easy to produce apnœa after tartar emetic has been injected into the blood and sulphate of zinc into the stomach. This could hardly be the case if the centres for respiration and vomiting were identical. I shall therefore speak of them as distinct.

The nervous centre for vomiting is usually excited to action

[1] Grimm, *Pflüger's Archiv*, iv. p. 205.
[2] Harnack, *Arch. f. exp. Path. u. Pharmakol*, ii. p. 285.
[3] *Ibid.*

reflexly by irritation of certain afferent nerves. They may be divided into two classes: (*a*) those which pass upwards from the body to the medulla, and (*b*) those which pass downwards to it from the brain. It is easy enough to allot a few nerves to one or the other of these classes, but there are many others which we cannot with certainty place in either division. Thus, the pharyngeal branches of the glosso-pharyngeal nerve pass upwards to the medulla and act upon it independently of the brain, for tickling the fauces will produce vomiting in a man whose cerebral faculties are so besotted with alcohol that he hardly feels blows or bruises which would cause him severe pain when sober. On the other hand, the nerves of taste and smell only act on the vomiting centre through the brain, for persons in the mesmeric sleep will drink the most nauseous mixtures with a smiling face, while the very remembrance of disgusting tastes, sights, and odours would make them sick in their ordinary waking condition. But we cannot so readily say how the vomiting centre is excited by those nerves which convey painful impressions from various parts of the body. Severe pain will often cause nausea and vomiting, although the pain may originate in the most various parts of the body. Thus, a person suffering from a loose cartilage in the knee-joint tells me that the pain it occasions always brings on nausea and vomiting. A painful wound may produce a similar effect, and Helmont[1] relates that after dislocating a joint, nausea and vomiting came on, and lasted until the bones were replaced. A blow on the testicles, an inflamed ovary, and the passage of a calculus along the gall-duct and ureter, all cause pain and often vomiting. Some say that the vomiting is due to the pain, and that it only lasts while the pain continues, the pressure of the calculus and the irritation it thereby causes having nothing to do with it. It may be the case, then, that the irritation of the nerves of a limb in the case of a loose cartilage or a dislocation, of the hepatic and renal nerves in the case of a calculus, and of the intestinal, ovarian, and other nerves, all act through the sensory portions of the brain; but it is not yet certain that they do so, and it is so much more convenient to represent them as going direct to the medulla, than as going round to it *viâ* the cerebrum, that I have given them a direct course in the accompanying diagram. In it I have represented the following as the afferent nerves which pass up directly from the body to the medulla oblongata, and excite to action the vomiting centre situated there:

[1] Quoted by Budge, op. cit., p. 15.

—Pharyngeal branches of the glosso-pharyngeal; pulmonary branches of the vagus; gastric branches of the vagus; gastric branches of the splanchnic; hepatic branches of the splanchnics (of the vagus ?); renal nerves; mesenteric nerves; uterine nerves; ovarian nerves; vesical nerves.

Those fibres which are represented as passing down from the brain may indicate the path by which the vomiting centre is

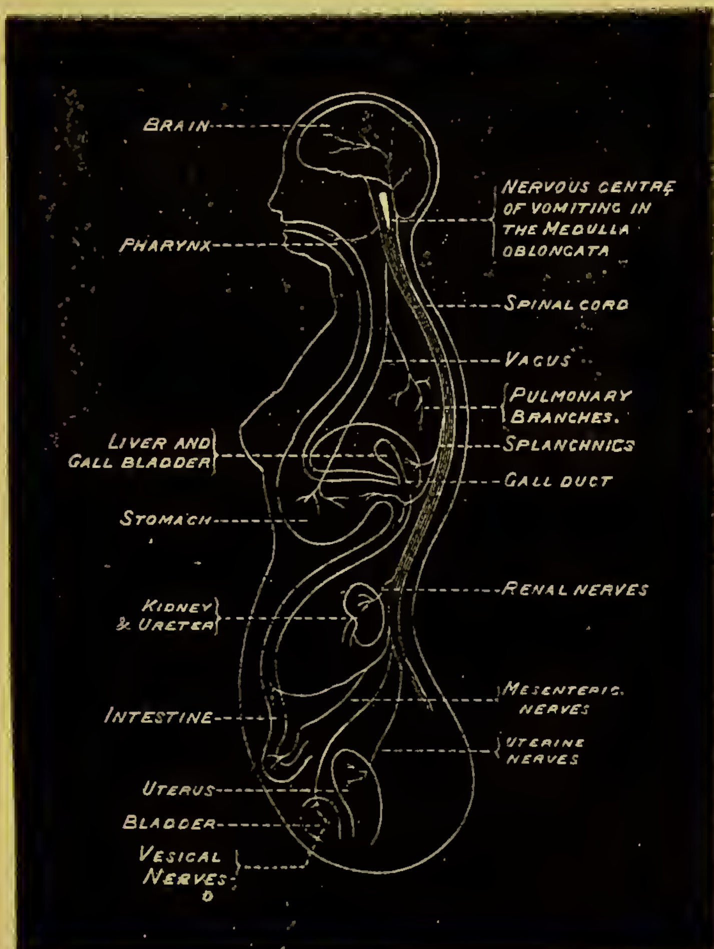

Fig. 20.—Diagram showing the afferent nerves by which the vomiting centre may be excited to action.

excited by impressions of sight, taste, smell; by simple recollections or imaginations; by blows on the head, or inflammation of the brain or its membranes.

After this general description, we will proceed to examine these nerves more particularly.

They are—1. The branches of the glosso-pharyngeal nerve,

distributed to the soft palate, root of the tongue, and pharynx.[1] Tickling these parts with the finger or with a feather is one of the readiest methods of inducing vomiting; and sometimes, as in cases of poisoning by mushrooms, the stomach can be emptied more readily by it than even by tartar emetic. When they are inflamed, they not unfrequently give rise to a cough, which is distinguished by violent expulsive efforts, nearly resembling retching, and not unfrequently accompanied by true retching, or even vomiting. This is often seen in children. One may frequently hear parents chide their children for coughing so noisily, and say to them, "Don't cough so loud," "Restrain your cough." Whenever these expressions are used, one may be almost certain that the chief cause of the cough is inflammation of the fauces, although this may sometimes be accompanied by bronchitis. 2. The gastric branches of the vagus and splanchnic nerves. It has been found by Blondlot and Bernard that when the mucous membrane of the stomach is gently tickled it becomes very rosy, and secretes gastric juice freely. If the mechanical irritation is carried further, so as to produce pain, the rosiness disappears and the surface becomes pale; the secretion of gastric juice is arrested; ropy mucus is poured out instead; and the movements of the stomach are much increased. At the same time the animal shows signs of uneasiness and nausea, and if the irritation be continued vomiting occurs, and bile has been observed to flow into the stomach.[2] Similar phenomena are produced by various kinds of food and medicine. Thus, the introduction of food into the stomach usually causes secretion of gastric juice; but when it is hard and indigestible, or irritating, it may arrest digestion and cause vomiting. Dilute bitter infusions give appetite, and seem to aid digestion; but a strong infusion of quassia will act as an emetic. As the vagi are the sensory nerves of the stomach,[3] and several of these phenomena can be produced by irritating their trunks, it is[4] probable that they have a good deal to do with the conduction of impressions from the stomach to the vomiting centre. But they are not the only afferent nerves from the stomach; for irritation of this organ will produce vomiting after they have been cut.[5] In this case it is probably through the splanchnic nerves that the irritation is conveyed to the medulla. 3. The

[1] Budge, *Die Lehre vom Erbrechen*, p. 131.
[2] Quoted in Carpenter's *Physiology*, 7th edition, p. 128.
[3] Budge, *Die Lehre vom Erbrechen*, p. 127.
[4] Rutherford, Trans. Roy. Soc. Edin., 18.
[5] Budge, op. cit., p. 94.

branches of the vagi and splanchnics going to the liver and gall-duct. Vomiting is of frequent occurrence in hepatitis, and during the passage of a calculus through the gall-duct.[1] It is probably due to irritation of these nerves; although, as we have already said, it is difficult to decide whether the nerves act directly on the medulla or only indirectly through the brain. 4. The pulmonary branches of the vagus. Irritation of these branches is not a very common cause of vomiting, and it may be doubted whether they cause vomiting directly or only indirectly. It is possible that the vomiting in the early stages of phthisis[2] may be due to these nerves, and it may be well to bear them in mind, and to examine the lungs in cases of vomiting without any obvious cause. 5. The renal nerves. Vomiting occurs in nephritis and when calculi are irritating the pelvis of the kidney or passing down the ureter. 6. The mesenteric nerves. Vomiting is almost always present in cases of strangulated hernia or intussusception. It also occurs in animals after a ligature has been tied firmly round a piece of the small intestine. It may be arrested by dividing the mesenteric nerves passing from the ligatured point.[3] Its occurrence in general peritonitis is probably due likewise to irritation of the mesenteric nerves. 7. The vesical nerves. It is somewhat doubtful whether the vomiting sometimes observed in cystitis is due to irritation of these nerves or to irritation of other nerves by the extension of the inflammation from the bladder to the adjoining parts.[4] 8. Uterine nerves. Irritation of these nerves is one of the commonest causes of reflex vomiting. It may be produced either by the presence of the fœtus in the uterine cavity, by inflammation of the womb itself, or by electrical irritation of the uterine plexus.[5] 9. Ovarian nerves. Vomiting is a symptom of inflammation of the ovaries.[6] 10. Irritation of various parts of the brain. Vomiting may be produced by mental states excited by a disagreeable taste, by the sight or smell of disgusting objects, or even by the mere recollection of these; by emotions, such as anger, suspense, grief, joy, &c.; continued and intense thought, &c.;[7] by concussion; by the irritation consequent on loss of blood, or caused by the with-

[1] Watson, *Practice of Physic*, 4th edition, pp. 586, 606.
[2] Craigie, *Practice of Physic*, vol. ii. p. 996; Watson, op. cit., vol. ii. p. 617.
[3] Schiff, Moleschott's *Untersuchungen*, Bd. x. p. 390.
[4] Craigie, *Practice of Physic*, vol. i. p. 930.
[5] *Pflüger's Archiv*, Bd. viii. p. 351.
[6] Hooper's *Physician's Vade Mecum: Oöphoritis.*
[7] Budge, op. cit., p. 153.

drawal of blood from the general circulation and its accumulation in the abdomen in cases of shock.[1] Vomiting is one of the most marked symptoms in meningitis and cerebritis, and is noticed also in some cases of tumours of the brain. Budge states that the cerebral centre for the movements of the stomach is the right corpus striatum and optic thalamus, especially the latter.[2] Irritation of these parts causes the stomach to move, while irritation of the corresponding parts on the left side of the brain have no action on the stomach whatever. From this observation we are led to suspect that when any irritation exists in the right hemisphere it will occasion vomiting more readily than irritation in the left hemisphere; and, according to Budge, this is actually the case.

There are thus many conditions of the brain which induce vomiting, and if we knew a little more about them we might separate them as we have done the nerves of the stomach, uterus, &c., instead of representing them all together, as we have done in the diagram. But even if we count them as one, we have altogether no less than ten nerves indicated in the diagram as exciting the vomiting centre reflexly. I shall not attempt to enter here on the means of diagnosing between the vomiting arising from irritation of all these nerves, but shall enter at once on the treatment.

As vomiting is generally a reflex act consequent on the irritation of some nerve, its rational treatment is either to remove the irritant, or, if this is impossible, to lessen the irritability of the nervous centre in the medulla, so that it no longer responds to the irritation. Not unfrequently we combine both methods. In inflammation of the fauces we use soothing or astringent gargles, confections, or glycerines. When the stomach is irritated by indigestible food or acrid matters present in its cavity, a large draught of warm water and mustard will often cause their ejection, and thus forms one of the best means for arresting further vomiting. If the irritant consist in an inflamed condition of the mucous membrane of the stomach itself, such treatment would be of little service, and we must endeavour to lessen the inflammation and to render the sensory nerves of the stomach less irritable. This we do by the use of bismuth and of hydrocyanic acid. It is well known that if one holds the finger over the mouth of a bottle of hydrocyanic acid for a few minutes it becomes numb

[1] *Practitioner*, vol. xi. p. 250.

[2] Budge, op. cit., p. 116.

and loses its sensibility; and we have every reason to suppose that the acid acts in the same way on the nerves in the wall of the stomach, so that the inflammatory condition present there no longer irritates them to the same extent. At the same time, however, we may give some drug to lessen the irritability of the vomiting centre in the medulla, such as morphia or chloral. Bromide of potassium has a considerable power to lessen most reflex actions, that of vomiting among the rest, and my friend Dr. Ferrier has used it with great success in sea-sickness. Acting on his suggestion, I have found the following formula very useful in gastric catarrh and subacute gastritis:—

℞. Bismuthi subnit, gr. x.
Potass. bromid., gr. xv.—xx.
Acid hydrocyan. dil., ♏ v.
Spt. chloroform, ♏ x.
Mucilag. tragacanth, fl. ʒ ij.
Aqua, ad. fl. ℥ j.
Sg. To be taken every three or four hours.

The medicine should be given about ten minutes before food, so as to diminish the irritability of the stomach and prevent the rejection of the nourishment, and it is often advisable to make the patient lie down on the left side either during or immediately after the meal. A tendency to vomit is often increased by lying on the right side. This is attributed by Budge[1] to the greater pressure exerted by the liver upon the stomach in this position, and this may be correct. It seems to me probable, however, that the mere weight of the stomach itself and of its contents will exert a drag upon it, directed more or less towards its pyloric end, either in the sitting posture or when recumbent on the right side. Now, the stomach is much more sensitive to any pull exerted in this direction than to one towards the cardia, even in the normal condition, and it is likely to be still more so when rendered hyperæsthetic by inflammation. I am therefore inclined to ascribe the benefit derived from lying on the left side to the absence in this position of any drag on the stomach and the irritation it would cause, rather than to any change in the relations of the liver.

I have already mentioned that it is doubtful whether irritation of the pulmonary branches of the vagus induces vomiting directly

[1] Budge, op. cit., p. 66.

in the same way as irritation of the gastric branches does; but vomiting, occasionally of a very obstinate kind, is certainly found in phthisis, and it may be due to this cause. When it seems to be caused by the cough, it is sometimes checked by doses of six to ten grains of alum. This is rather hard to explain on the supposition that the vomiting is here due to the irritation of the pulmonary nerves, for the alum can have but little sedative action either on the lungs themselves or on the medulla. If we look at a patient coughing and mark the swollen veins on the forehead and neck, and remember that these are merely the visible signs of the general congestion throughout the whole venous system, including the veins of the stomach, we can hardly help thinking that the constant distension of the gastric veins during the almost incessant paroxysms must either in itself act as an irritant and thus induce vomiting, or lead to such a condition of the gastric mucous membrane as will do so. If this be so, the action of alum as a local astringent in removing congestion of the stomach may well explain its beneficial effect in arresting vomiting.

The same principles prevail in the treatment of vomiting due to irritation of the other abdominal nerves as of those of the stomach; but in them we can less easily soothe the irritation by local means, and we are obliged to depend still more on remedies which will act on the medulla. But we by no means neglect to remove the irritant as far as possible. In hepatitis we strive to subdue the inflammation by blisters and depletion; in intussusception we try to restore the bowel to its normal condition by copious injections of water or oil; in strangulated hernia we relieve the incarcerated bowel by an operation; and in inflammation of the uterus, ovaries, and bladder, we have recourse to depletion, blisters, and other appropriate local remedies. Even in pregnancy, if other means fail, we are sometimes obliged finally to remove the irritant by inducing premature labour, and sacrifice the offspring in order to save the life of the mother.

But in such cases we base our hopes of arresting vomiting rather on our ability to diminish the excitability of the vomiting centre by means of opium, bromide of potassium, chloral, or hydrocyanic acid, than our power to remove the irritant.

In sea-sickness it is difficult to say what the irritant is which excites the vomiting centre to action. For my own part, I am inclined to believe that it is the shaking and dragging of the abdominal viscera caused by the motion of the ship. Subjective

sensations point unmistakably to this as the cause, and the testimony they afford is strengthened by the fact that the sickness becomes less troublesome if the movements of the abdominal viscera are restrained by a tight bandage applied externally, or even by distension of the stomach with food. Whatever be the cause, however, the treatment is chiefly directed to the vomiting centre, and my friend Dr. Ferrier has found bromide of potassium in large doses of especial service in preventing as well as arresting the distressing nausea and vomiting which make many persons regard a trip across the Channel with perfect horror.

Thus far we have directed our attention to the act of vomiting, chiefly with the view of arresting it. Sometimes, however, we wish to induce it, and for this purpose we employ various substances which are generally all classed together as emetics. They naturally divide themselves into two subdivisions. Those belonging to the one act, like mustard, only when introduced into the stomach; those belonging to the other act like tartar emetic, both when introduced into the stomach and when injected into the veins. The first class includes, besides mustard, the sulphates of zinc and copper, as well as other irritant substances not usually employed as emetics: they induce vomiting reflexly by irritating the nerves in the stomach; and as the effect they produce is the same as that of scratching the mucous membrane, they are sometimes called mechanical emetics. The second class includes tartar emetic, ipecacuanha with its active principle emetia, and apomorphia; as well as veratria, delphinia, cyclamin, asclepiadin, and sanguinarin, which also cause vomiting when injected into the veins, but are not used medicinally as emetics.

It used to be considered certain that emetics of this class produce vomiting by acting directly on the nervous centre in the medulla oblongata, to which they were conveyed by the blood, and not by exciting it reflexly through irritation of the stomach, like the mechanical emetics. This view seems to be to a certain extent correct, and the vomiting which follows the injection of such a substance as tartar emetic into the veins is probably partly due to its direct action on the vomiting centre, but partly also to its reflex action on this centre through irritation of the stomach. For, as Buchheim has pointed out,[1] when emetics are injected into the blood, they are carried by it to the stomach as well as to the nerve centres, and thus they may irritate it and induce vomiting in exactly the

[1] Buchheim, *Arzneimittellehre*, 1853-56, p. 304.

same way as if they had been passed into it through the œsophagus. Tartar emetic, for example, will cause vomiting, either when injected into the veins or when swallowed, but in both cases it reaches the mucous membrane of the stomach and irritates it. It is true that when injected into a vein it reaches the vomiting centre also, but when swallowed it is sometimes rejected almost entirely, so that little or none reaches the vomiting centre. In both cases, then, the emetic acts on the stomach, but only in one does it act on the medulla. Yet vomiting occurs in the one case as well as in the other, and it is therefore only natural to attribute it to the action

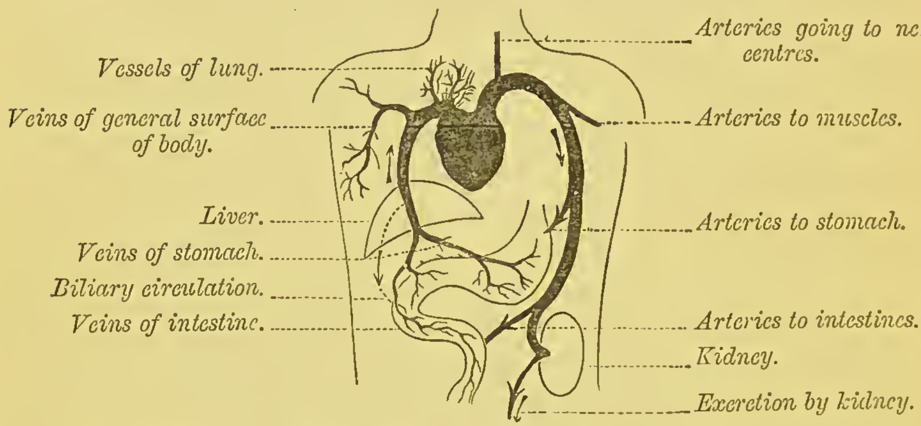

Fig. 21.—Diagram to show that emetics, &c., when absorbed by the superficial vein, will be carried both to the stomach and nerve centres.

on the stomach, and not to its action on the medulla. Besides, tartar emetic only precipitates albumen when in presence of an acid; the gastric juice in the stomach therefore causes it to precipitate the albumen in the mucous membrane. This produces irritation and inflammation in it, when no change whatever can be detected, either by the naked eye or the microscope, in other organs, such as the medulla.[1] It may thus be fairly said that, until we do find a change in the medulla, we ought to ascribe the vomiting only to the action of the emetic on the stomach.

But having said thus much on the one side of the question, let us turn to the other, and see what arguments may be adduced in proof of the action on the medulla being the true cause of vomiting. First of all comes the somewhat staggering fact, that after Magendie had removed the stomach of a dog altogether and replaced it by a bladder, the animal vomited when tartar emetic

[1] Ipecacuanha does so also. Gubler, *Comment. Thérap.*, 1868, p. 627; and D'Ornellas, *Bull. de Thérap.*, tome lxxxiv. p. 199.

was injected into the veins. If the drug only caused vomiting by irritating the stomach, how can it do so after the stomach is removed? Hermann,[1] who supports the gastric action of tartar emetic, tries to get over this difficulty by supposing that it irritates the mucous membrane of the œsophagus and pharynx, and that the vomiting in Magendie's experiments was induced by its action on these parts. This explanation may be correct, but these parts, instead of being acid, like the stomach, are alkaline, like the medulla, and there is therefore no reason why the tartar emetic should act on them rather than the nervous centre. This experiment of Magendie's in itself affords great support to the old doctrine of the central action of tartar emetic, and recent experiments on the action of apomorphia render it strongly probable that apomorphia, another emetic of the same group, likewise acts on the medulla directly. Apomorphia, although of recent introduction, having been discovered by Mathiesson in April 1869, and first investigated by Gee a month afterwards, bids fair to supplant other emetics, as it is so rapid and certain in action, and can be applied either subcutaneously or administered by the mouth with equal ease. Gee noticed that small doses of $\frac{1}{5}$ of a grain caused vomiting in dogs, and large ones occasioned in addition a curious *manége* movement, the animals running round in a circle [2] in somewhat the same way that Longet noticed them to do after a wound of the optic thalamus.[3]

This effect of apomorphia points to an action of the drug in the nervous centres, and is all the more interesting when we remember that Budge placed the cerebral centre for the stomach in the right thalamus.

Gee's experiments were repeated and extended by Siebert,[4] who noticed that apomorphia produced great acceleration of the respiration, pointing distinctly to excitement of the respiratory centre, which is closely connected with the centre for vomiting. Now, the respiratory centre, like the vomiting centre, may be excited reflexly by irritation of the vagi; but Harnack,[5] in a recent research, has found that the excitation caused by apomorphia is not reflex, but is due to the direct action of the drug on the respiratory centre

[1] Hermann, *Pflüger's Arch.* v. p. 280.

[2] Gee, *Clinical Society's Transactions*, vol. ii. p. 168.

[3] Longet, *Traité de Physiologie.*

[4] Siebert, *Untersuch. über d. physiol. Wirkungen des Apomorphins.* Inaug. Diss. Dorpat, 1871, p. 60.

[5] Harnack, *Arch. f. exp. Pathol. u. Pharmakol.*, Bd. ii. p. 283.

itself. As this centre and that for vomiting are so closely connected, it seems a fair inference that the apomorphia acts directly on the vomiting centre also, and produces emesis by irritating it. As both tartar emetic and ipecacuanha excite the respiratory centre also, it is probable that like apomorphia they act directly on the medulla, and thus we are led back to the old notion of the central action of this group of emetics. But as these are such weighty arguments in favour of their reflex action, we can hardly help coming to the conclusion that they may act either centrally or reflexly, and in all probability usually combine the two actions whenever they are introduced into the blood. When apomorphia is injected subcutaneously or into a vein, a smaller dose is sufficient to produce vomiting than when it is introduced into the stomach,[1] while a larger dose of tartar emetic must be injected than would be sufficient if administered by the mouth. This seems to show that the emetic effect of apomorphia is due chiefly to its action on the medulla, and less to its action on the stomach, while tartar emetic acts less on the medulla and more on the stomach. It has been already mentioned that tartar emetic only acts as a powerful irritant when it comes in contact with an acid, especially hydrochloric acid, as it does in the healthy stomach. Consequently, its irritant action on the stomach will be much less if the hydrochloric acid usually present in the organ should be diminished or absent. Now, it has been found by Manasseïn[2] that the proportion of acid in gastric juice is diminished, or the acid altered, during the febrile condition; and clinical experience long ago showed that tartarated antimony did not exert its usual emetic action in persons suffering from pneumonia, or, as physicians were accustomed to express it, there was a tolerance of the drug.

The employment of emetics is not nearly so extensive now as it formerly was. They may be administered (1) for the simple purpose of evacuating the contents of the stomach and duodenum; (2) for the effect of the muscular movements during vomiting upon other organs; (3) for their effect on the nervous system.

In cases of poisoning, the first thing to be done is to remove the poison from the stomach, and thus prevent it either from injuring the gastric walls themselves or from being absorbed into the blood. We usually employ sulphate of zinc or of copper as an emetic for this purpose.

[1] Greve, *Berlin. Klin. Wochensch.*, 1874, p. 351.

[2] Manasseïn, *Virchow's Archiv*, 1872, lv. p. 413.

In indigestion, the case of the patient is often really one of slight poisoning, although we are rarely accustomed to regard it as such. Not only do the undigested articles of food act as mechanical irritants to the stomach, but they undergo fermentation, and the products of this are real poisons. Butyric acid, for example, is frequently produced by the fermentation of food in the stomach, and, as Otto Weber has shown, it is a powerful poison. The same is the case with the sulphuretted hydrogen, which gives the disagreeable odour of rotten eggs to the eructations of some patients. The irritating matters in the stomach not unfrequently cause nausea and headache, without leading to vomiting; but if they should be ejected, nausea generally ceases. Therefore, the best treatment frequently is to give copious draughts of warm water, or warm water and mustard. We use warm or tepid water because cold lessens the irritability of the stomach, and thus prevents emesis altogether; and we add the mustard in order to stimulate the gastric walls. But it is not those matters only which have been introduced into the stomach which are evacuated by vomiting. A quantity of the gastric secretions is also ejected, and anything they may happen to contain is thus removed from the body.

In a former paper[1] I explained that certain substances, when swallowed, were absorbed by one part of the intestinal canal, excreted by another, and again re-absorbed, so that they may sojourn a long time in the body before being finally eliminated (*vide* p. 201). Thus iodide of potassium is absorbed by the stomach, excreted by the salivary glands, and re-absorbed by the stomach, so that it goes round and round in the gastro-salivary circulation. Most metals, lead probably among the rest, are excreted in the bile and absorbed by the small intestine, so that they go round in the entero-hepatic circulation. Purgatives, by hurrying the secretions through the intestinal tube, prevent re-absorption to some extent, and thus aid in the expulsion of the metals or other substances they contain. But it is much further from the duodenum to the anus than from the duodenum to the mouth; and anything taking the longer route is much more likely to be absorbed than if it took the shorter way. In violent vomiting, bile is evacuated by the mouth without getting a chance of re-absorption; and a course of emetics, therefore, seems far better suited to remove bile and anything contained in it—such as lead or copper—than a course of purgatives can be. It is not

[1] *Practitioner*, vol. xii. p. 408.

improbable that it is so; and a mixed course of emetics and purgatives is really exceedingly useful in lead-poisoning;[1] but the discomfort which attends vomiting causes a very decided preference to be given to purgatives. Nor are metals the only substances which circulate in this way; bile itself does so, and its removal by vomiting gives relief in biliousness. Lussana[2] also thinks that malarial poison, whatever that may be, circulates with the bile in the portal system; and it is exceedingly interesting to learn that the natives of Morocco, as my friend Dr. Duckworth informs me, having no quinine, actually treat intermittent fevers by emetics. It is stated also by eminent physicians that an emetic at the beginning of a continued fever, such as typhus, is of great service; and it is possible that it acts there in the same way as we suppose it to do in intermittent fevers, viz. by removing the fever poison.

The violent expulsive efforts in vomiting do not act only on the stomach; they affect also the lungs and expel anything in the air-passages still more effectually than can be done by coughing. Emetics are therefore used in croup and bronchitis. The gall-bladder is also much compressed by the descending diaphragm, and the bile is forced through the common bile-duct, instead of trickling through it with almost no pressure at all, as it usually does. Any obstruction in the duct which the ordinary pressure of the bile would never move, will then be pressed on into the duodenum, unless it be too firmly impacted. Gall-stones in the duct, and jaundice depending on the obstruction they occasion, can thus be removed by the action of emetics; but there is always the danger that, if the obstruction is at all firm, the violent efforts may burst the gall-bladder and lead to the death of the patient.

Finally, emetics may be used to produce an "impression on the nervous system,"—a vague term which may mean anything or nothing, and may be explained by every one as best he pleases. The facts are, that in cases of epilepsy, where the fits tend to recur every few minutes and the unconsciousness may last for hours, an emetic may sometimes put an end to the attack. An impending ague fit may sometimes be arrested by an emetic given just before it is expected to begin.[3] It may be also useful in hysterical fits; but these are so readily arrested by a galvanic shock, that few would think of using anything else while a battery is at hand.

[1] *Dictionnaire des Sciences Médicales*, 1815, tome ii. p. 522.

[2] Lussana, *Lo Sperimentale*, tome xxix., 1872, p. 358.

[3] *Materia Medica*, &c., by H. C. Wood, p. 362.

It seems probable that the nervous excitement which causes the epiletic or other fit, discharges itself in the exertion of vomiting, but it would take too long to enter on this subject here.[1]

To sum up, the chief points in relation to vomiting and the action of drugs upon it are :—

1. Vomiting consists in two factors, viz. (1) the simultaneous compression of the stomach by the abdominal muscles and diaphragm, and (2) the opening of the cardiac orifice by the contraction of the longitudinal fibres of the œsophagus.

2. When innervation is disturbed, these two factors do not occur together, and thus retching may occur without vomiting.

3. The movements of vomiting are correlated by a nervous centre in the medulla oblongata, from which impulses are sent down through various motor nerves to the muscular structures engaged in the act.

4. This nervous centre is probably closely connected with the respiratory centre, but is not identical with it.

5. It is usually set in action reflexly by irritation of the pharyngeal, gastric, hepatic, enteric, renal, uterine, ovarian, and possibly also by the pulmonary and vesical nerves which come from the periphery towards it. It may also be excited by impressions sent down to it from the brain.

6. Vomiting may be arrested in two ways, either by removing the irritant which is exciting the vomiting centre, or by lessening the excitability of the centre itself, so that it no longer responds to the impressions made on it from without.

7. Emetics may be divided into two classes: those which act only on the stomach, and those which act on the vomiting centre also.

8. Tartar emetic probably acts in both ways. Tolerance of it is probably due to want of hydrochloric acid in the stomach.

9. Emetics may be used to evacuate the stomach and duodenum. They thus remove irritating matters, poisons generated in the stomach by putrefaction, bile, and metals or fever poisons (such as that of ague) circulating in the entero-hepatic circulation.

10. They may be also used to empty the bronchi and gall-bladder, or to cut short epileptic and to prevent ague fits.

[1] See Lauder Brunton on *Inhibition*, West Riding Asylum Reports, 1874.

ACTION OF MERCURY ON THE LIVER.

(*'British Medical Journal' for January 5th*, 1873.)

THE valuable report of the Edinburgh Committee of the British Medical Association on the Action of Mercury on the Liver added very largely to our knowledge of the subject, without altogether settling a great many important questions concerning the therapeutics of the drug.[1]

Few physicians who have had any practical experience of the use of mercurial purgatives in cases of so-called "biliousness," will deny that their immediate effect is decidedly beneficial, although many may be deterred from employing them by the belief that, once begun, they must be continued, and will ultimately prove highly injurious to the patient.[2] The relief occasioned by a blue pill and a saline purgative is a matter of every day observation; but the *modus operandi* of the mercury is a question on which much difference of opinion prevails, and any attempt to answer it must depend, to a considerable extent, on the view taken of the pathology of "biliousness." Do the dull, heavy, and languid feelings, the disinclination to exertion, mental or bodily, the irritable or peevish temper, the failing appetite, the muddy complexion, and dingy conjunctiva, which most persons know, alas! too well, owe their origin to catarrhal changes in the gastric and intestinal mucous membranes alone? or is popular pathology partly right in ascribing them to "bile in the blood" or a "sluggish liver"? For our part, we are inclined to hold the latter opinion, and to believe that not without reason are the disappearance from the eyes of the

[1] *Report of the British Association*, 1868, p. 187, and *Brit. Med. Journ.*, 1868, vol. ii. pp. 78 and 176, and 1869, vol. i. p. 411. For an excellent *résumé* of the literature on this subject, see Fraser's article in the *Edinburgh Medical Journal*, April, 1871.

[2] Prout, *Stomach and Renal Diseases*. 5th Edition, p. 52.

yellowish tinge which seems as if it only required to be somewhat deepened to become jaundiced, and the coincident appearance of bile in the stools after a mercurial purgative, pointed to as proofs that too much bile in the blood is (partly at least) the cause of biliousness, since with its removal from the system the symptoms disappear. So long as it was supposed that bile was formed in the blood, and only separated from it by the liver, such a view as this might meet with ready acceptance; but how are we to reconcile it with the doctrine of most physiologists, that bile is not separated from the blood by the liver, but is formed within that organ itself? Fortunately, this is not difficult, for Schiff has shown that we have been latterly accustomed to take too narrow a view of the functions of the liver, and that it separates bile from the blood, or, as we may term it, excretes, as well as forms or secretes it.[1] This he did by tying the ductus choledochus in dogs, and putting a cannula into the gall-bladder, so that he could collect the whole of the bile secreted by the liver. Immediately after the operation the flow of bile was abundant, but in the course of half an hour it became greatly diminished, and remained so, never again reaching the amount at first observed. This curious result Schiff found to be due to the bile being all removed from the body by the cannula, instead of passing, as it normally does, into the duodenum, whence it is reabsorbed into the blood, and again excreted by the liver. In the first half-hour after the fistula was made, the liver was excreting bile as well as forming it, and so more flowed from it than in any subsequent period when it was only forming bile.

Whenever Schiff introduced bile into the blood, either by injecting it directly into the veins, or putting it into the duodenum, stomach, or areolar tissue, the flow of bile from the liver was at once increased, but again diminished when the additional bile had been excreted. By another series of experiments, he also found that not only can a certain quantity of bile be present in the blood without producing jaundice, but that it probably is always present. We thus see that, normally, a great part of the bile goes round in a circle, from the liver into the duodenum, thence into the blood, so to the liver again, while another part is carried down by the contents of the intestine, and, after becoming more or less altered, passes out of the body with the fæces.

Let us now consider what the result will be if the quantity of

[1] *Pflüger's Archiv*, 1870, p. 598, and Lussana, *Lo Sperimentale*, tom. xxix. 1872, p. 337.

bile circulating in this way should be increased. All observers are agreed that abundant food increases the secretion of bile; and we will suppose that this has been done by continued good living and a succession of heavy dinners, such as most Englishmen are accustomed to indulge in at Christmas time. The stomach and intestines, in all probability, also become disordered, and it would be hard to say what part of the condition in which the patient then finds himself is to be assigned to them and what to the bile; but this we can readily see, that all the symptoms that an excess of bile in the blood can produce, short of jaundice, will be occasioned; nor can these be removed by any purgative medicine, which, like aloes, will merely act on the large intestine. The colon may be cleared of its contents, but the bile will go on undisturbed in its accustomed round. Very different, however, will be the result if a purgative be administered which will act on the duodenum, as we will assume mercury to do, more especially if it be combined with such an one as sulphate of magnesia, which will act on the rest of the bowels. The mercury stimulates the duodenum to peristaltic contraction, the bile is hurried rapidly downwards, the remainder of the intestine is likewise contracting vigorously, and in a short time all chance of reabsorption is gone, for the bile has been finally evacuated. All excess of bile has thus been got rid of, and, as far as it is concerned, the liver, duodenum, and other organs may now go on performing their functions in the normal way, until some fresh indiscretion on the part of the patient again causes a disturbance.

In the account we have just given of the action of a mercurial purgative, we have assumed that it acts on the duodenum. Now, this we cannot at present directly prove; but we have the indirect proof afforded by the fact, observed by Radziejewski,[1] that leucine and tyrosine, which are products of pancreatic digestion, appear in the fæces after the administration of mercurials, as well as that yielded by the large evacuations of bile which calomel produces, and which, as Buchheim has shown,[2] really give their characteristic green colour to the so-called "calomel stools." By thus causing elimination of bile, and lessening the amount circulating in the blood, calomel acts as a true cholagogue, in the sense in which the word was employed by those physicians who looked upon the liver

[1] Reichert u. Du Bois Reymond's *Archiv*, 1870, p. 1.

[2] Buchheim, *Arzneimittellehre*, p. 262. See also Scott, *Archives of Medicine*, No. iii. p. 224, and Mosler, *Virch. Arch.*, xiii. p. 41.

merely as an excreting organ, although, as modern experiments have proved, it may lessen the amount actually secreted. This it can do in a double fashion, for not only does it diminish the quantity which has to be excreted by the liver in the manner already explained, but, as the Edinburgh Committee of the British Medical Association have shown, it likewise lessens the formation of bile. In their experiments, the diminished secretion which followed mercurial purgation could not be due to the prevention of reabsorption, for the whole of the bile was regularly removed from the body as quickly as it was secreted, and we are, therefore, obliged to attribute it to diminished formation. What the cause of this may be, we are not at present in a position confidently to state; but we know that fasting lessens the formation of bile, and if the food be hurried out of the intestine by a purgative before it has time to be absorbed, it might just as well not have been eaten at all.

We have now seen how an excess of bile may be present in the blood without the liver being either "sluggish" or "torpid;" and it seems to us that the difference of opinion which has hitherto prevailed regarding the action of mercurials is in great measure due to attention having been directed to the amount of bile poured out from the liver, instead of to what is of much more importance in reference to "biliousness"—viz. the quantity which remains in the blood after a dose of blue pill or calomel.

ON THE ACTION OF PURGATIVE MEDICINES.

(' *The Practitioner*,' VOL. XII. *May and June* 1874.)

BEFORE entering upon their use, it will be well to consider the question—How do certain substances act as purgatives?

It is generally believed that most purgatives increase the number of the stools, and render them more fluid in a double manner; firstly, by stimulating the intestine to increased peristaltic action, and secondly, by inducing a discharge of fluid from its mucous surface, and thus to some extent washing out its contents.[1] Some purgatives, such as aloes, are supposed to act almost entirely by stimulating the peristaltic movements, their effect on the secretion from the intestine being almost *nil;* while others, like bitartrate of potash, are supposed to induce a very free secretion from the mucous membrane, while they have so little influence upon the peristaltic movements that the fluid poured out from the intestinal wall after their use may remain in the torpid intestine so long as to be again reabsorbed.[2] Others again, like croton oil, are supposed to increase the flow of liquid into the intestine, and at the same time to stimulate the peristaltic movements.

This view of the action of purgatives is the one generally held in this country. It is supported by several French authorities, but is rejected by some of the most eminent German pharmacologists.

All are agreed in believing that the action of many purgatives is due to their power of quickening peristaltic action, but several German authors are inclined to regard increased peristalsis as the only, or almost the only, cause of purgation, and to deny that there is any increased flow of fluid from the intestinal walls. They consider that purgative medicines, by quickening the peristaltic action,

1 Pereira's *Materia Medica*, vol. i. p. 247; Stillé's *Therapeutics and Materia Medica*, vol. ii. p. 404; Ringer's *Therapeutics*, 3d ed. p. 154.

2 Garrod's *Materia Medica*, 3d ed. 1868, p. 401.

cause the contents of the intestine to be hurried along and expelled per anum before there has been time for the absorption of their fluid constituents. Instead, therefore, of the stools being firm and consistent as in the normal condition, they are loose and watery like the fæcal matters which one usually finds in the small intestine on post-mortem examination. By making a fistulous opening in the ascending colon of a dog, Radziejewski, the distinguished pharmacologist, whose untimely death is much to be deplored, has found [1] that the intestinal contents, when poured from the small into the large intestine, almost exactly resemble the stools produced by the use of purgative medicines. He therefore, and several German authors who follow him, attribute the watery condition of the stools observed after the administration of vegetable purgatives, such as castor or croton oil, to increased peristalsis only. The objection may be raised that the stools produced by elaterium, for example, are more watery than the contents of the small intestine usually are; but this can readily be met. For it is not merely the peristaltic action of the large intestine which is quickened so that the fæces are expelled in much the same condition as they entered it. The movements of the small intestine are also accelerated, so that little absorption can take place in it, and its contents will therefore leave it in a more watery condition than usual, and being quickly hurried through the large intestine, will produce a liquid motion.

This explanation may seem satisfactory enough in regard to the action of vegetable purgatives, and of such mineral ones as calomel; but it hardly explains the effects of salines, such as bitartrate of potash or sulphate of magnesia. These are allowed by Buchheim [2] to have an additional action besides that of increasing peristalsis. They retain water with great avidity, they diffuse slowly, and by thus preventing the water which is taken with them or swallowed shortly afterwards from being absorbed, at the same time that they quicken the intestinal movements, they wash out the whole alimentary canal from end to end, in much the same way as a simple injection washes out the rectum. A large quantity of fluid is normally poured into the intestine by the liver, pancreas, and intestinal glands, and this alone, according to Kuhne,[3] is greater than the amount expelled in the most profuse diarrhœa. When,

[1] Reichert u. Du Bois-Reymond's *Archiv*, 1870, p. 95.

[2] Buchheim's *Arzneimittellehre*, p. 136.

[3] Kuhne, *Lehrbuch der physiologischen Chemie*, p. 151.

in addition to this, the quantity of fluid ingested by the mouth is taken into consideration, it seems perfectly unnecessary to believe that any increased flow of fluid takes place from the intestinal walls. Moreover, direct experiments seemed to show that purgatives did not increase the flow of fluid from the intestinal walls. Such a flow might be of two kinds: it might consist of a transudation from the blood-vessels, as supposed by Schmidt,[1] or of a secretion from the intestinal glands. In the former case it would contain a considerable quantity of albumen like the fluid in ascites or pericarditis; while in the latter, albumen might only be present to a very slight extent. A consideration of the structure of the intestine alone is sufficient to show the improbability of a direct transudation of fluid from the vessels: but Radziejewski[2] has set the matter at rest by examining the composition of fæces before and after the use of purgatives, and proving that the stools produced by them do not contain albumen to anything like the amount they ought to do if transudation fluids were present in them to any considerable extent. The most decisive experiments, however, were those which were first made by Thiry by means of the intestinal fistula which bears his name. These seemed to show in the most conclusive manner that purgatives neither increased the flow of fluid from the intestinal walls by transudation nor by secretion. In order to discover exactly what went on in the intestine, Thiry conceived the idea of isolating a portion of it and attaching one end of this piece to an opening in the abdominal walls while its nerves and vessels remained uninjured, and the whole piece was as nearly as possible in a normal condition. He therefore divided the jejunum or ileum in two places, a few inches apart from each other, sewed up one end of the piece thus isolated, and attached the other end to the wound in the abdomen. The short *cul-de-sac* thus formed remained attached to the mesentery and received its vascular and nervous supply as usual. The divided ends of the intestine were then sewn together, and the continuity of the alimentary canal restored.[3] This is represented in the accompanying figure (Fig. 22), where B indicates the place where the piece C D, which originally lay between A B and B E, has been cut out, and the two ends of A B and B E sewn together so that the alimentary canal is again complete though a few inches shorter than before. F, G, D, is the

[1] C. Schmidt, *Characteristik der epidemischen Cholera.* Leipzig, 1850, p. 99.

[2] Radziejewski, op. cit. p. 75.

[3] Thiry, *Sitzungsbericht der Wiener Academie*, 1864, vol. L. p. 77.

abdominal wall, and *a* and *b* are the vessels and nerves in the mesentery.

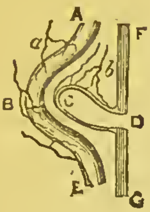

Fig. 22.

The little bag of intestine C D can be easily reached from the outside of the body, and the result of any experiment upon it readily ascertained. It apparently remains in a perfectly healthy condition, and when tickled with a feather readily secretes intestinal juice. But a purgative medicine introduced into it neither increases the secretion nor causes transudation from the vessels, although the drug produces brisk purgation if administered to the animal by the mouth. Thiry[1] in his experiments used croton oil, senna, and sulphate of magnesia. Schiff[2] repeated them with aloes, jalap, and sulphate of soda; and Radziejewski[3] with croton oil and sulphate of magnesia. All these observers obtained a like negative result. Further proof seems superfluous to show that purgatives act only by accelerating peristaltic action, and not by increasing the flow of fluid from the intestinal wall; and I have not only believed but have taught this, till the publication of some experiments of Moreau,[4] their verification by Vulpian, and the results I have myself obtained on repeating them, have led me to alter my opinions.

These experiments were made by opening the abdomen of an animal, and tying four ligatures tightly round the small intestine a few inches apart from each other, so as to isolate three portions of intestines (Fig. 23). A purgative medicine was then injected by means of a subcutaneous syringe into the middle part, and the intestine being then returned into the abdominal cavity, the wound in the abdominal parietes was sewn up. A few hours afterwards the animal was killed, and on examination the middle portion of intestine, into which the purgative had been injected, was found full of fluid, while the portion on each side was completely empty. All three pieces having been equally empty at the commencement of the experiment, and all three having been placed under exactly the same conditions, we cannot attribute the copious secretion into the middle loop to any other cause than the action of the purgative injected into it. Moreau's experiments have been

[1] Thiry, op. cit., p. 95.
[2] Schiff, *Nuove ricerche sul polere degerenle*, &c. Il. Morgagni, July 1867, p 5.
[3] Radziejewski, op. cit., p. 85.
[4] Moreau, *Archiv Générales de Médecine*, August 1870, p. 234.

repeated by Vulpian,[1] and I subjoin the notes of the results which I have obtained.

Exp. I.—A cat was chloroformed, and an incision about $1\frac{1}{2}$ inches long made through the abdominal walls in the middle line about the umbilicus. A coil of small intestine was drawn out, and four ligatures tied tightly round it so as to isolate three loops of intestine. One-hundredth of a drop of croton oil mixed with one drop of alcohol was then injected into the second loop by means of an extremely fine Wood's syringe. (The quantity

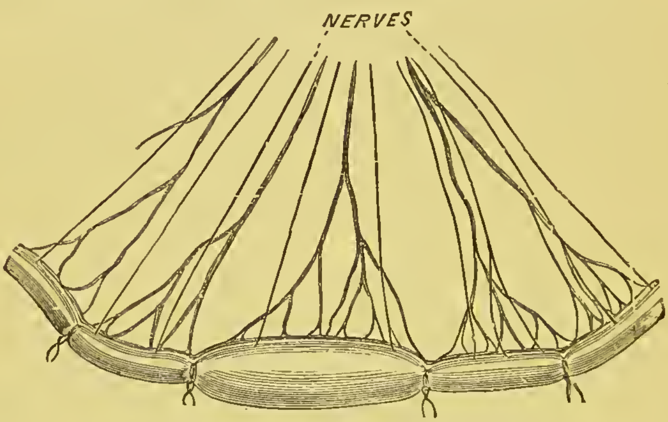

Fig. 23.

of croton oil was obtained by thoroughly mixing 1 part of oil and 99 of alcohol) The intestine was then replaced, the wound sewn up, and the animal allowed to recover from the chloroform. About four hours and a quarter afterwards it was instantly killed by a single blow on the head with a hammer, and the intestine examined :—

Loop 1.	Length $3\frac{6}{10}$ inches	. . .	Contained 7 minims of fluid.
„ 2.	„ $1\frac{7}{10}$ „	. . .	„ 20 „ „
„ 3.	„ $3\frac{4}{10}$ „	. . .	„ 10 „ „

Exp. II.—A cat was operated on in the same way as the first, and $\frac{1}{10}$ of a drop of croton oil with 10 drops of alcohol was injected into a loop of intestine which, as in the former case, lay between two others likewise isolated by ligatures. About four hours and a quarter after the operation the cat was killed in the same way as the first :—

Loop 1.	Length $2\frac{9}{10}$ inches	. . .	Completely empty.
„ 2.	„ $3\frac{2}{10}$ „	. . .	Contained 80 minims of fluid.
„ 3.	„ $3\frac{1}{10}$ „	. . .	Empty.

[1] Vulpian, *Bulletin Général de Thérapeutique*, tome lxxxiv. 1873, p. 522.

Exp. III.—Made in the same way as the preceding ones. One drop of croton oil and 9 of alcohol injected into loop No: 2. Four hours and a quarter afterwards :—

Loop 1.	Length $4\frac{9}{10}$ inches	. . .	Empty.
„ 2.	„ $5\frac{9}{10}$ „	. . .	Contained 110 minims of fluid.
„ 3.	„ $6\frac{4}{10}$ „	. . .	Empty.

Just about the middle of loop No. 2 the mucous membrane or about $1\frac{1}{2}$ inch was thickened, much reddened, and inflamed.

Exp. IV.—Made in the same way as the preceding ones. Ten drops of croton oil were injected into loop of intestine No. 2. I am not quite certain that the whole of the 10 drops found their way into the intestine, as the oil passed very slowly through the fine hollow injecting needle, although considerable force was used. The syringe at one instant became detached from the needle, and a little oil escaped. I tried to guess the right amount, however, and injected it afterwards. Four hours and a quarter after injection :—

Loop 1.	Length $6\frac{7}{10}$ inches	. . .	Contained 155 minims of fluid.
„ 2.	„ $5\frac{7}{10}$ „	. . .	„ 180 „ „
„ 3.	„ $5\frac{3}{10}$ „	. . .	„ 75 „ „

The fluid, as measured, was not quite accurate, for a tapeworm was present in the intestine, and parts of it helped to swell the apparent bulk of the fluid.

In the middle loop of No. 2 the mucous membrane was much inflamed for about two inches or rather more. This is the part with which the oil would come in contact after its injection through the intestinal wall.

The mucous membrane of all three loops, as well as that for four or five inches above the upper and below the lower loop, was much thickened, and the lumen of the intestine partially filled with a glairy fluid. Above and below these parts the intestine was firmly contracted and natural, just as when the injection was made. The mucous membrane in all the coils was somewhat pale, as also at the thickened parts outside. At the other parts where it appeared unaltered, its inner surface was of a yellow colour, probably from adherent biliary or fæcal colouring matter.

Exp. V.—A cat was experimented on as before. A small quantity of elaterin (probably about $\frac{1}{15}$ of a grain) suspended in 30 drops of water was injected into loop No. 2. About four hours and a quarter afterwards :—

Loop 1.	Length $5\frac{3}{10}$ inches	. . .	Contained 60 minims of fluid.
„ 2.	„ $6\frac{1}{10}$ „	. . .	„ 110 „ „
„ 3.	„ $5\frac{5}{10}$ „	. . .	Empty.

In all three loops, as well as for five or six inches beyond the loops, the mucous membrane (or whole intestinal wall?) was pale and somewhat thickened.

Exp. VI.—A cat was chloroformed, an incision made in the abdominal walls, and three loops of intestine isolated by ligatures. Into the middle one (No. 2) about two grains of gamboge made into an emulsion, with about 60m. of water, were injected at 11.15. The wound was then sewn up, and the animal allowed to recover. About four hours afterwards the cat was killed by a blow on the head and the intestine examined:—

Loop 1.	Length $4\frac{1}{8}$ inches	. .	Empty. Mucous membrane yellowish on the surface.
„ 2.	„ $5\frac{6}{8}$ „	. . .	Contained 185 minims of yellowish turbid fluid with numerous flocculi. The surface of the mucous membrane was slightly paler than in No. 1.
„ 3.	„ $6\frac{2}{3}$ „	. . .	Empty. Colour like No. 1.

Exp. VII.—The experiment was performed on a cat in the same way as the previous one. Into the middle loop of intestine about one grain of jalapin in a small quantity of spirit (proof) and water (equal parts) was injected. The intestine was examined about four hours afterwards. The cat seemed sleepy, and the respiration appeared to be impeded by fluid in the respiratory passages:—

Loop 1.	Length $5\frac{1}{8}$ inches	. . .	Quite empty. Surface of mucous membrane normal.
„ 2.	„ $6\frac{1}{2}$ „	. . .	Contained 17 minims of tenacious fluid. Surface of mucous membrane moister than in No. 1.
„ 3.	„ $5\frac{1}{2}$ „	. . .	Mucous membrane moist. Covered with bloody mucus.

Exp. VIII.—The experiment was made in the same way as the preceding ones. Into the middle loop, No. 2, about 7 grains of sulphate of magnesia dissolved in 105 minims of water were injected. Into each of the side loops 105 minims of water were injected. The intestine was examined about four hours afterwards:—

Loop 1.	Length 5 inches . . .	Quite empty.
„ 2.	„ $7\frac{1}{2}$ „ . . .	Contained 320 minims of fluid. This was of a pale amber colour and glairy consistence, mixed with flakes of whitish mucus. Not the slightest trace of congestion was noticeable. Mucous membrane was quite natural in No. 2.
„ 3.	„ $5\frac{1}{2}$ „ . . .	Quite empty.

Exp. IX.—The experiment was conducted like the others. Into the middle loop of the cat's intestine 85 minims of a saturated solution of sulphate of magnesia were injected. On examination four hours afterwards, the middle loop, which was $7\frac{1}{2}$ inches long, contained 425 minims of fluid. The other two loops were quite empty.

Exp. X.—The experiment was conducted as before. Into the middle loop of the cat's intestine about 90 minims of a saturated solution of sulphate of magnesia were injected. The loop was about 6 inches long. After about five hours the loop was found to contain about 250 minims of fluid. The loop above it contained a little bloody mucus, the one below it was entirely empty.

These experiments show that croton oil, elaterin, gamboge, and sulphate of magnesia all cause a copious secretion from the intestine. Jalapin did not do so in the single instance in which it was tried; but I am not quite certain that the whole of it went into the intestine, as it formed a resinous mass which I had considerable difficulty in getting to pass through the nozzle of the syringe. The fluid contained in the intestine after the use of the other purgatives appears to be a secretion, not a transudation, for it does not contain much albumen as a transudate would do. In Exp. VIII. it amounted to about 42 minims, and in Exp. IX. to about 56 minims per square inch of intestine acted on by the purgative. The greatest secretion was caused by sulphate of magnesia; next came croton oil, elaterin, and gamboge; while jalapin stood last of all.

Such positive results as these seem to prove that purgatives do cause a flow from the intestinal wall, quite as conclusively as experiments with Thiry's fistula do the opposite; and as the conditions under which the purgatives act on the intestines more nearly approach the normal in Moreau's than in Thiry's experiment, there can be but little doubt that purgatives produce a

decided secretion of fluid from the intestine, as well as accelerate peristaltic movements.

Having now come to a conclusion regarding the manner in which purgatives act, let us consider some of their effects upon the body. It is evident that the increased peristaltic action of the bowels will hurry along the food and cause its expulsion before the nutritive matters it contains have been fully absorbed.

If a purgative be taken immediately before or shortly after a meal, the result will be much the same as if less food had been taken or the meal entirely omitted. Many persons who are accustomed systematically to eat more than they require will regularly take a "dinner pill" or a course of Seidlitz or Pullna waters, although they cannot be persuaded to deprive themselves of a single opportunity of enjoying the pleasures of the table or to put the least restraint upon their appetites.

Increased peristaltic action will also remove fæcal matters as well as food from the intestine, and it will be greatly assisted in this by the increased secretion from the intestinal wall which purgatives induce.

I have already mentioned that mechanical irritation, such as tickling with a feather or rubbing with a glass rod, will cause secretion from the *cul de sac* of intestine in Thiry's fistula, and hardened fæces seem to have a similar action. Thus diarrhœa is not unfrequently caused by the presence of scybalous masses or other irritating matters in the intestine, and nothing cures this like a dose of castor-oil. At first sight it seems odd that the scybala are not washed away by the fluid which they cause to be secreted, but this secretion will probably be poured out only at or below the point where they lie, and thus it will have little effect on them, though it may wash out the lower part of the bowel thoroughly enough. A dose of castor-oil, on the contrary, will induce secretion in the bowel above the scybala, and the fluid in its downward rush will carry the fæcal masses along with it.

Irritating substances in the intestine, besides acting locally upon the bowel in the manner just indicated, may exercise an influence upon distant organs through the medium of the nervous system. Sir Charles Bell[1] observed a case in which ulceration of the ileum was found in a man who had suffered severely from tic, but there was nothing wrong whatever with the fifth nerve, in which the pain was felt. He therefore felt convinced that although the pain was

[1] Bell, *Practical Essays*, p. 85.

felt in the cheek, its true source was irritation in the ileum. Acting on this belief, he administered croton oil ($\frac{1}{12}$ of a drop in combination) in tic douloureux for the purpose of removing any morbid condition of the bowel, and obtained the happiest results from its employment; and Newbigging[1] has found it equally efficacious in sciatica.

It is difficult to say whether the pain felt in the cheek is simply due to the irritation of the intestinal nerves being reflected, as it is termed, along the fifth nerve, or whether the irritation induces such a change through the vaso-motor nerves in the blood-vessels of the cheek as actually to set up a new irritation in the course of the fifth nerve itself. At any rate, the vessels of the face and head are very easily affected by any irritation of the stomach or intestines, as is easily seen from the extraordinary pallor which at once overspreads the face when a state of sickness and nausea has been induced. The effect of constipation in causing a feeling of fulness in the head is well known, and Ludwig and Dogiel[2] found that when the intestines of an animal were moved by the finger the rapidity with which the blood flowed through its carotid arteries was greatly increased. The frontal headache which so frequently accompanies gastric or intestinal derangement may possibly be due to some of the intestinal contents which ought to be evacuated being absorbed and acting as poisons on the vessels of the head themselves. I am inclined to think, however, that although this may have much to do with it, yet the headache very often depends to a great extent on some alteration in the cerebral circulation caused reflexly by the condition of the abdominal organs; for I have myself had a headache, though not a frontal one, which alternated with nausea. The nausea would last for a few minutes, during which the headache would entirely disappear; then the nausea would leave me, and the headache instantly took its place. After evacuation of the stomach, both the headache and nausea disappeared, showing that in this instance at least they were due to irritation in the stomach. But in many instances no doubt, not only headache but much more serious symptoms may be due to the decomposition of food in the intestinal canal and the absorption of its products. Thus Senator[3] relates a case where a simple gastric catarrh without fever was brought on by eating something

[1] Newbigging, *Edin. Med. and Surg. Journ.*, Jan. 1, 1841.
[2] Ludwig's *Arbeiten aus der physiologischen Anstalt zu Leipzig*, 1867, p. 253.
[3] Senator, *Berliner Klinische Wochenschrift*, 1868, No. 24, p. 254.

which disagreed with the patient. This was followed on the second day by great belching of gas, smelling like sulphuretted hydrogen or rotten eggs. The urine also contained sulphuretted hydrogen. As soon as this occurred the patient collapsed suddenly, and became pale and giddy, with a small, frequent, and compressible pulse. The patient remained conscious, and in a minute and a half or two minutes the collapse passed away. A similar attack came on again during the same day, but after the bowels which had been constipated were opened, the patient rapidly recovered. Senator considers that the collapse was due to poisoning by the sulphuretted hydrogen absorbed from the intestine, and it certainly seems probable that this was one cause of the attack, even if it were not the only one.

Other poisons besides sulphuretted hydrogen may be formed in the alimentary canal and absorbed into the blood, where they exert their deleterious action. Among these may be mentioned butyric acid, which has frequently been found in the stomach in considerable quantities.[1] According to O. Weber[2] it is very poisonous, exerting its action chiefly on the nerve-centres. The nervous symptoms which frequently accompany gastric derangement or disease of the intestines may therefore be frequently occasioned by poisons formed in the alimentary canal in consequence of imperfect digestion.

The administration of a brisk purgative or small doses of Epsom salts thrice a day is a most effectual remedy for frontal headache when combined with constipation; but if the bowels are regular, the morbid processes on which it depends seem to be checked and the headache removed even more effectually by nitro-hydrochloric acid or alkalies given before meals. If the headache is immediately above the eyebrows, the acid is best; but if it is a little higher up, just where the hair begins, the alkalies appear to me to be more effectual. At the same time that the headache is removed, the feelings of sleepiness and weariness which frequently lead the patients to complain that they rise up more tired than they lay down, generally disappear.

Somewhat analogous to the neuralgia of the fifth nerve in Sir Charles Bell's case, or to frontal headache, is the pain which we frequently meet with in persons having decayed teeth. The pain may be felt in the offending tooth itself, but very often it seems to

[1] Kühne, *Physiologische Chemie*, p. 58.
[2] O. Weber, *Deutsche Klinik*, 1864, p. 488.

give little or no uneasiness. The patients complain of neuralgic pains above the ear or along the jaw, and will often deny that they have any decayed teeth at all. It would almost seem that neither the irritation in the tooth nor irritation in the intestine alone is sufficient to produce pain, though they do so when acting conjointly; for extraction of the tooth, or stoppage of the cavity with cotton-wool steeped in melted carbolic acid, will often remove the pain although no medicine is given internally, while on the other hand a brisk purgative may also afford relief though the tooth be left untouched. It is best, however, to combine both methods of treatment, and if the tooth is not extracted or stopped, the pain is very apt to return; and it seems to me probable, though I am by no means certain of it, that this recurrence is connected with the renewal of gastric or intestinal irritation. According to Heincken,[1] otalgia may also depend on the presence of irritating matters in the intestine; and Sir Charles Bell observes that accumulations in the colon will give rise to pains in the loins, spermatic cord, or groin. Pain at the lower angle of the scapula is referred by him to disorder and distention of the duodenum. This pain is very often accompanied by flatulence, and is described by patients as a "pain in the pit of the stomach shooting through between the blade-bones," and it is not unfrequently termed by them "windy spasms." It is relieved by rhubarb and alkalies given before meals.

Having said so much regarding the fæcal contents of the intestine and their local and remote actions, we must now consider a matter of no less importance, viz. the effect of purgatives upon the secretions which are poured into the intestinal tube by the various glands connected with it. The saliva which flows into the mouth from the submaxillary and parotid glands is swallowed and aids the digestion of starchy food in the stomach, and probably the intestine. A part of its active principle, ptyalin, is reabsorbed, and some of it is excreted in the urine;[2] but as we shall hereafterwards see, it is probable that another part is excreted again by the salivary glands and thus does its work twice over. This is at present only a probability as regards ptyalin, but it is a certainty in the case of several substances which are excreted by the salivary glands, such as iodide of potassium, for example,

[1] Heincken, *De Morbis Nervorum ex Abdomine*, quoted by Sir Charles Bell, op. cit., p. 9.

[2] Cohnheim, *Virchow's Archiv*, xxviii. p. 250.

which can be detected with great ease. When this substance is swallowed, it is absorbed from the stomach, passes in the blood to the salivary glands, and is excreted by them much more readily than by the kidneys. It again passes down with the saliva to the stomach, is reabsorbed, and again excreted. Thus it may go round and round for a long time without getting entirely out of the body. (See gastro-salivary circulation, Fig. 24.) If we wish to remove it quickly and completely, we must give a purgative so as to prevent its reabsorption from the intestinal canal by causing its speedy expulsion. The same is the case with other iodides, such as those of lead or iron. Iodine has been shown by Bernard to possess the power of making iron pass readily through the salivary glands, the iodide of iron being found in the saliva soon after it has been injected into the blood, while other salts of iron, such as lactate, never make their appearance in it at all.[1] Several years ago iodide of potassium was proposed by MM. Guillot and Melsens as a remedy in cases of lead-poisoning. The lead, they consider, is present in the body in the form of an insoluble compound[2] which it makes with the tissues, but by the administration of iodide of potassium it is rendered soluble. It then finds its way into the circulation, and is excreted by the kidneys and other emunctories. But the iodide of lead is partly excreted by the salivary glands, for M. Malherbe, of Nantes, and Dr. Sieveking have found it in the saliva of persons suffering from lead-poisoning, and who were being treated by iodide of potassium. The lead salt being swallowed with the saliva, is again reabsorbed, and thus the cure is comparatively slow when patients are treated with iodide of potassium alone. I frequently see patients suffering from lead-poisoning brought on by working in white lead, and for some time I have been accustomed to treat them with five grains of iodide of potassium, three times a day, and a sufficient quantity of sulphate of magnesia or other purgative either thrice or once a day, to keep the bowels very freely open, and cause the expulsion of the lead from the alimentary canal as quickly as it is secreted into it. I have not made comparative experiments on the effect of this treatment and of that by iodide of potassium alone, or by purgatives alone, but from what I remember of cases treated by the late Professor Syme with castor-oil, I am fully satisfied with the treat-

[1] Bernard, *Physiologie Expérimentale*, tom. ii. p. 99.

[2] Guillot and Melsens, *Archives Générales de Médecine*, 4th sér. iv. p. 517; and Melsens, *Annales de Chimie*, June 1849.

ment I now adopt. The same plan would probably prove equally useful in chronic poisoning by copper or mercury.

But the gastro-salivary circle, as we may term it, from stomach to salivary glands and from salivary glands to stomach again, is not the only one in which those metals move. Their circulation in

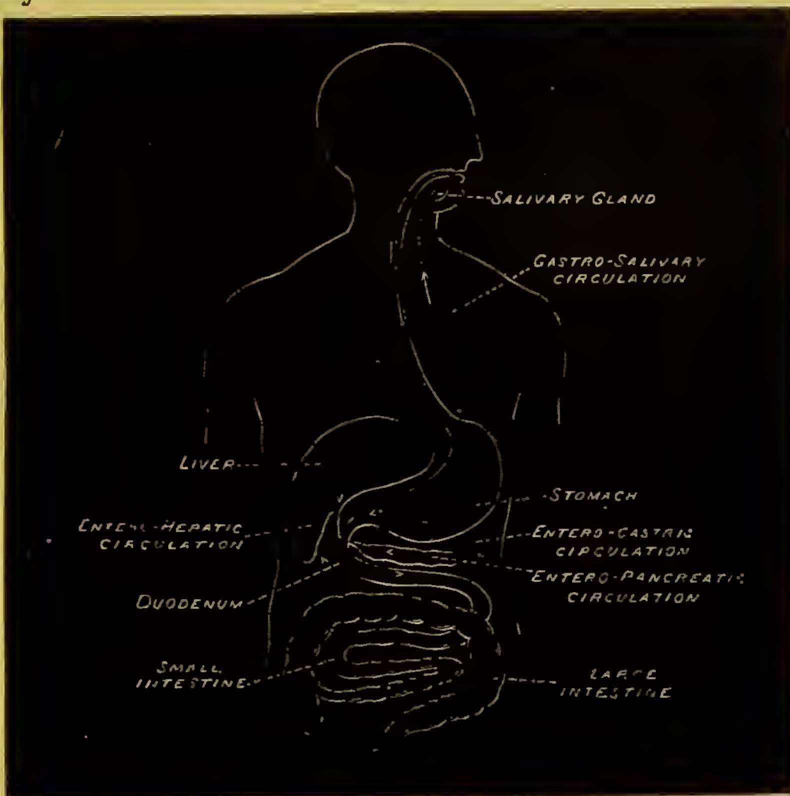

Fig. 24.—Diagram showing the manner in which substances are excreted by one organ and reabsorbed by another, so that they circulate a long while in the organism before being expelled.[1]

the portal system, or entero-hepatic, as it is termed by Lussana,[2] is still more important. (See Fig. 24.) Iron is eliminated in great part by the bile: copper and manganese appear in it also, according to Albini and Moser,[3] and it seems probable that manganese,

[1] The absorption of substances excreted by the salivary gland is indicated in the figure as taking place in the stomach, and their circulation is called gastro-salivary; but it is very probable that a considerable portion of them passes through the stomach into the intestines, and that *entero-salivary* might be a better term. Similarly, the absorption of bile has been represented as taking place in the duodenum, and that of pancreatic and gastric juices in the jejunum, but this is only to avoid confusion in the drawing, and not to indicate the part of the intestine where absorption really takes place.

[2] Lussana, *Lo Sperimentale*, tom. xxix. 1872.

[3] Quevenne, Albini, and Moser, quoted by Lussana, *Lo Sperimentale*, tom. xix. 1872, pp. 340, 343.

lead, and all the heavy metals pass out of the body by this channel. From the liver they pass into the intestine, are reabsorbed from it, and again pass to the liver and recommence their course. They may be present in considerable quantities in the blood of the portal system without reaching the general circulation or getting a chance of passing out in the urine. They are therefore much more closely locked up in the entero-hepatic circulation than in the gastro-salivary one, for the salivary glands are supplied by the systemic circulation, and any blood which brings lead or any other substance to them must also carry it to the kidneys. The power of the entero-hepatic circulation to retain metals within the body being much greater than that of the gastro-salivary one, it is evident that the beneficial effects of purgatives in lead-poisoning are due to their removing the metal from the portal circulation still more than their action on the gastro-salivary one which has already been discussed. Other poisons, such as curare and probably serpent's venom, may also circulate in considerable quantity in the portal system without reaching the systemic circulation, and probably this is one of the causes, though by no means the only one, which renders these substances to a great extent innocuous when swallowed.[1]

But the circulation of iron, lead, curare, &c., in the portal system, important though it may be, is of far less interest than the circulation of the bile itself. For the sake of convenience I have merely stated that lead, mercury, &c., are excreted in the bile, and have hitherto assumed that bile circulates in a similar way in the portal system, without giving any reason for doing so.

It used to be thought by many that bile was formed in various parts of the body, and was simply excreted by the liver. This view is now given up by most physiologists, who believe that bile is formed by the liver only. But in altering their views regarding the function of this organ they went too far, and supposed that it only formed bile, which, when it had once found its way into the intestine and mixed with the intestinal contents, became decomposed and finally expelled with the fæces. A year or two ago, however, Schiff[2] found that this view of the hepatic functions was too limited, and that the liver removed bile from the blood or *excreted* it as well as formed or *secreted* it.[3] He observed that when

[1] Lussana, op. cit. [2] Schiff, *Pflüger's Archiv*, 1870, p. 568.

[3] Although it is not correct to do so, I use the term "secreted" here as synonymous with "formed," for the sake of conveniently distinguishing between the formation of bile in the liver and its removal from the blood.

all the bile was drawn away from the liver by means of a fistulous opening in the gall-bladder after ligature of the ductus choledochus, the quantity which flowed from the liver rapidly diminished after the fistula had been established, but could again be quickly increased by the simple process of putting bile into the duodenum. The bile was at once absorbed and again excreted by the liver, and it did not make much difference whether the bile just removed from the fistula in a dog was again injected into its duodenum, or whether ox bile was used instead. In the normal state of the animal the liver is always doing two things: it is *forming* new bile, and it is *excreting* old bile which it has received from the intestine by means of the portal vessels. When a biliary fistula is made and the bile is drawn away as fast as it is secreted, none gets into the intestine, and therefore no old bile reaches the liver; consequently, the quantity collected represents only the new bile formed in the liver, and is of course much less than that which would normally pass through the ductus choledochus into the intestine. If all the bile were absorbed there would be no need for the liver to go on forming it, but this is not the case, for only a part of it is reabsorbed, and the remainder is decomposed and excreted with the fæces.

So long as the liver does its duty properly, and excretes again all the bile which is absorbed by the portal blood from the intestine, very little bile can pass through the organ into the vena cava and thence into the general circulation. But whenever so much bile is taken up from the intestines that the liver cannot excrete it all, it will find its way out of the portal into the systemic circulation, and will exert an injurious action on the nervous system. The same effect will follow anything which diminishes the excreting power of the liver and renders it unable to excrete the normal amount. It is evident that if anything should cause the liver to form more bile than usual at any time, it will have extra work to do in the way of excreting it after its absorption, and there will be more bile circulating in the portal blood for some time afterwards, or at any rate until the extra quantity has been got rid of or compensation has been established by the liver forming less. Many experiments have shown that an abundant supply of food causes the liver to form more bile, and we all know that heavy dinners are apt to cause biliousness. Fasting, on the other hand, diminishes the quantity of bile secreted, and every one knows that if he fasts for a day after taking an especially heavy dinner he may be none

the worse for it, but if he dines out every night he is almost sure to become bilious unless he takes measures to prevent it by using purgatives.

It has not yet been shown by direct experiment that the symptoms usually grouped under the head of "biliousness" are due to the presence of an excess of bile in the blood; but the rapidity with which they disappear after the removal of bile from the system, either by vomiting or purgation, renders it extremely probable. Frequently we find that the fit of vomiting which has expelled a quantity of bile is hardly over when the appetite returns, the brownish-white fur disappears from the tongue, the face loses its dingy hue, the languor disappears, the irritability of temper is replaced by equanimity, and stupidity and laziness give place to sprightliness and activity. But vomiting is a disagreeable process, and few submit willingly to it, although it would be well worth while if the same end could be gained by no other means. As most old practitioners have found, however, a mercurial pill and a saline purgative produce all the good effects of vomiting without its trouble and discomfort, and they have long been in the habit of ascribing the beneficial action of the mercury to its "cholagogue" properties. They felt convinced that biliousness was due to bile in the blood, and believed that its removal was due to the liver being stimulated by the mercury to excrete the bile more rapidly. But the careful experiments made by the Edinburgh Committee of the British Association[1] on dogs with biliary fistula showed that neither mercurials nor other purgatives increased the flow of bile from the liver, and these results seemed at first sight to contradict the views entertained by most practitioners regarding their cholagogue action. The contradiction is apparent, but not real, for in the experiments the bile was regularly removed from the body as soon as it was formed, and none of it ever reached the intestine. Consequently, any diminution in the quantity collected simply showed that the liver was forming less. Other experiments have given somewhat different results from those of the Edinburgh Committee, and Röhrig[2] has found that the administration of purgatives, as well as other measures which increase the circulation in the portal system, augment the formation of bile. The important question in regard to the treatment of biliousness, however, is not whether the liver forms more or less new bile, but whether the bile

[1] *Report of the British Association*, 1868, p. 214.
[2] Stricker's *Medicinische Jahrbucher*, 1873, p. 250.

already circulating in the blood is removed from it. The liver may be doing its best to effect this purpose, but it will not succeed if the bile it removes from the portal blood is again absorbed as quickly as it is poured into the intestine. But if the peristaltic action of the whole intestinal canal is quickened by a purgative, the bile will be hurried rapidly onwards and evacuated before there has been time for its reabsorption, and the liver being thus relieved will be able to excrete any bile still remaining in the blood. This result will not be affected by any purgative acting on the large intestine alone, for a considerable part of the bile will in all probability have been absorbed before it gets so far; but any simple purgative or mixture of purgatives which stimulates the duodenum and small intestine as well as the large one will prove most effectual. Now, the green colour which the fæces present after the administration of mercurials, and which is so distinctive that the name of "calomel stools" has been applied to them, has long been regarded as an evidence of bile and appealed to as a proof of the cholagogue action of these remedies. The opponents of this doctrine have declared that the colour was simply caused by the presence of black sulphide of mercury, just as a somewhat similar colour may be occasioned by the presence of a small quantity of sulphide of iron after the administration of mild ferruginous preparations. Their statement has been disproved by Buchheim, who has shown that the colour is really due to bile, and thus established the fact that calomel induces its expulsion from the intestine. It may therefore well be called a cholagogue, and it is evident from what has already been said that it must diminish the quantity circulating in the blood, whatever its effect may be on the amount formed by the liver.

Other substances besides bile are found in calomel stools, and among the most important of these are leucin and tyrosin. These bodies are produced by the action of pancreatic juice on albuminous substances, and their presence, which was discovered by Radziejewski, indicates that the contents of the duodenum and small intestine have been expelled before much absorption has taken place. Now, the duodenum not only contains half-digested food and bile, but also the gastric and pancreatic juices and the ferments to which they owe their activity. It is generally taken for granted that after these ferments have once aided in digesting a meal they are destroyed or evacuated, and no importance, so far as I know, has ever been attached to their reabsorption.

It appears from the experiments of Brücke, who found pepsin in the muscles,[1] that it is reabsorbed, at least in part, and is indeed excreted in the urine, as is also a diastatic ferment derived from the saliva or pancreas.[2] Pancreatic ferments also are probably absorbed, for Hüfner has found ferments possessing like them the properties of digesting fibrin as well as converting starch into sugar in the salivary glands and lungs.[3] If these ferments, then, are poured into the intestine and absorbed from it again in the same way as bile, it seems highly probable that they also are excreted by the same glands which formed them. (See entero-gastric and entero-pancreatic circulations, Fig. 24.) The function of the gastric follicles and pancreas would thus be a double one like that of the liver, and they would constantly excrete the ferments absorbed from the intestine and brought to them by the blood, as well as form new quantities of them to replace those which were carried off in the fæces or destroyed in the process of digestion. This view derives some probability from the observation of Schiff, that after the stomach has already digested a copious meal and become empty its power to digest albumen is almost entirely lost,[4] and the fact noticed by Bernard that when the pancreatic juice is drawn away by means of a fistula, what flows from the gland some time after the operation frequently does not possess the power of digesting albumen like the juice which has been collected immediately after the insertion of the cannula.[5] These facts have been explained in a different way by Schiff and Bernard, but it seems to me that the explanation just given supplements without excluding theirs, and clears up some points which they have not touched.

There is this important difference between the glands just mentioned and the liver, viz. that the bile can circulate in the portal system between the liver and intestine without reaching the systemic circulation, but the gastric and pancreatic ferments absorbed from the intestine cannot reach the stomach and pancreas again without mixing with the general current and the blood, and being conveyed to other organs as well. Pepsin cannot act in an alkaline fluid like the blood, but pancreatic ferment can;

[1] Brücke, *Sitzungsbericht der Wiener Academie*, 1861, xliii. pp. 622, 619.

[2] Cohnheim, *Virchow's Archiv*, xxviii. p. 250.

[3] Hüfner, *Journal für practischen Chemie*, vol. v. p. 372.

[4] Schiff, *Physiologie de la Digestion*, tom. ii. p. 195.

[5] Bernard, *Physiologie Expérimentale*, tom. ii. p. 229 ; compare also p. 223, where he states that the juice becomes watery towards the end of digestion.

and although I do not know that any experiments have been made with it, yet Binz and Siegen found that a ferment derived from the liver, and possessing like the pancreatic one a diastatic power, raised the temperature of an animal when injected into it.[1] This rise was due to its action as a ferment, and not to its mere presence in the blood as a foreign body, for it had no action whatever when it was injected after its fermentative power had been destroyed by boiling. It is therefore quite possible that the temperature of the body is normally maintained to some extent by means of the pancreatic ferments circulating in the blood, and if purgatives diminish its quantity in the way I have supposed they will tend to lower the temperature.

It must be remembered that these are only suppositions as yet, and require much further substantiation, but they help us at any rate to form some idea of the way in which purgatives prove useful when given at the commencement of a fever. They also give us some notion of the reason why persons so often take cold after the use of purgatives, and one of the dangers of their administration to old people, who produce little heat at any rate, and can only slowly form new supplies of any ferment once carried away.

It is possible that purgatives have an additional action in remittent and intermittent fevers due to malaria, and even in continued fevers due to other poisons. Lussana supposes that the malarious poison which certainly produces some of its most marked effects on the spleen and liver, circulates like other poisons in the portal circulation.[2] If this hypothesis be correct, purgatives may be productive of benefit by removing part of the poison as well as by lessening the temperature.

The pancreatic and gastric ferments have a very positive and certain use in digesting food in the intestine, even should they not possess the hypothetical action in the blood to which I have just referred; and if they are usually absorbed and excreted again, a constant course of purgatives will seriously diminish their quantity. In consequence of this, the digestion of food will be carried on slowly and imperfectly, and the general health will suffer. But this will only be the case if purgatives are used which act on the whole of the bowels, for those which affect the

[1] Siegen, *Ueber die pharmacologischen Eigenschaften von Eucalyptus Globulus.* Inaugural Dissertation. Bonn, 1873, pp. 32, 34.

[2] Lussana, op. cit., p. 358.

large intestine only will interfere but slightly with the ferments, a considerable portion of which will probably have been absorbed before they get so far. We can thus perfectly understand how a constant course of blue pill[1] and black draught[2] may have most disastrous consequences, while an aloetic pill may be swallowed nightly for months together, without doing any appreciable harm.

The experiments of Moreau and Vulpian, as well as my own, show that a large quantity of fluid is drained away from the blood into the intestine by the action of purgatives, and we can thus readily understand their use in removing fluid in dropsies. The abstraction of so much fluid will tend to empty the blood-vessels, and at the same time the irritation caused by the purgatives will attract a larger proportion of blood to the intestinal vessels, and thus still further lessen the blood-pressure in other parts of the body. The blood being no longer urged onward with the same force, the congestion in any inflamed part diminishes, and the painful throbbing which is felt at every pulsation when certain parts of the body are inflamed will be diminished, or may disappear, at least for a time. The diminished tension in the arteries which purgatives induce is clearly seen from the accompanying sphygmographic tracings, which I owe to the kindness of Mr. Mahomed.

When the kidney is the organ affected, the benefit afforded by purgatives will be twofold, for they both diminish the work it has to do by eliminating water by the bowels, and at the same time lessen congestion, and thus remove an impediment to the proper performance of its function. Accordingly the administration of a purgative such as elaterium is found to lessen and sometimes to remove albumen from the urine, to render the secretion copious even when no diuretic has been given, and greatly to increase the activity of diuretics, which may have been unable to produce any action so long as the bowels were left alone.[3]

In conclusion I give a short *résumé* of the chief points in this paper. Purgatives act by stimulating the secretion of fluid from the intestines, as well as by increasing peristaltic action. They prove useful in many ways. They hurry the food out of the alimentary canal, and thus lessen the injurious effects of over-eating. By expelling irritating substances from the intestine they

[1] Prout, *Stomach and Renal Diseases*, 5th ed., p. 52.

[2] Pancreatic ferment appears in the fæces after the use of senna. (Radziejewski, Reichert, and Du Bois-Reymond's Archives, 1870, p. 72.)

[3] Geo. Johnson, *Brit. Med. Journal*, 1868, March 7, p. 215.

arrest diarrhœa, and remove headache and other pains, caused either by the abdominal irritation or by the absorption of poisonous matters produced by imperfect digestion and decomposition of food. They relieve biliousness by removing bile, and are most efficient aids in the treatment of chronic poisoning by lead, mercury, or

Fig. 25 is a sphygmographic tracing from the pulse of a healthy man before taking a purgative. The somewhat oblique rise, slow descent, and comparatively slight dichrotism of the pulse-wave indicate that the arterial tension is moderately high.

Fig. 26 is a tracing from the same person after the use of a purgative. The more abrupt rise and quicker fall, and decided dichrotism of the pulse-wave, as well as the greater frequency of the pulse, as indicated by the shortness of the waves, show that the tension in the arteries is much less than in Fig. 25.

other metals. It is probable that pepsin and pancreatic ferment are absorbed from the intestine and circulate in the blood, where the latter assists in the production of animal heat. They are then secreted anew by the stomach and pancreas, and do their work again. Purgatives lessen their quantity as well as that of the bile; and they thus may be useful in fevers, but they injure old and feeble persons, both by diminishing their calorific power and impairing their digestion. They relieve inflammation by lowering the blood-pressure and thus diminishing congestion; and they prove beneficial in dropsies, both by abstracting water from the blood and diminishing congestion in the kidneys.

HOW TO MAKE A POULTICE.

(' *The Practitioner,*' VOL. XXIX., *Oct.* 1882.)

AT first sight the title of this paper may seem to many of my readers absurd, and the idea that medical men require any instruction in making a poultice preposterous, but I have been led to write it from seeing that many students and some practitioners do not distinguish between the proper methods of making a poultice for surgical and for medical use. Many, perhaps most, students spend a great part of their four years' curriculum in surgical study, and devote a comparatively small portion of it to medicine. This may partly be the reason why they do not learn the best ways of making poultices for the relief of internal pain: but another reason is, that in hospitals poultices are made in certain ways for the sake of cleanliness and economy, and these ways are not always the best possible for private patients, although they may be the best under the conditions which obtain in hospitals. Every one knows the relief which a poultice affords when the finger is inflamed, and has noticed how the painful throbbing diminishes after its application. Most people have noticed also that dipping the finger in cold water has a similar action, and it seems strange to many that the opposite conditions of heat and cold should have a similar effect. The reason probably is that both heat and cold lessen the force of the impulse with which the blood is driven through the dilated arteries of the inflamed parts against the block which exists in the capillaries. Cold causes the afferent arteries to contract, and lessens the impact of the blood by diminishing the quantity sent to the inflamed part; a poultice lessens the impact by dilating the capillaries surrounding the seat of inflammation, and affording a ready side outlet into the veins. In surgical cases we usually use the warmth and moisture of the poultice to act directly on the surface. We

therefore make the poultice with crushed linseed or with linseed meal and oil, spread it on some tow and apply it to the skin without anything intervening. But useful though this method may be for wounds, ulcers, and abscesses, it is not the best form of application in cases of inflammation of the thoracic or abdominal viscera, or where spasm is present without inflammation. In such cases we may, no doubt, do some good by applying the poultice to the surface exactly as in surgical diseases. We may draw off some of the blood to the surface; and we may also exercise a reflex action through the nerves upon the vessels of the inflamed organ below, but this will not be so great if we influence the surface only, as when we allow the heat to penetrate to the inflamed or

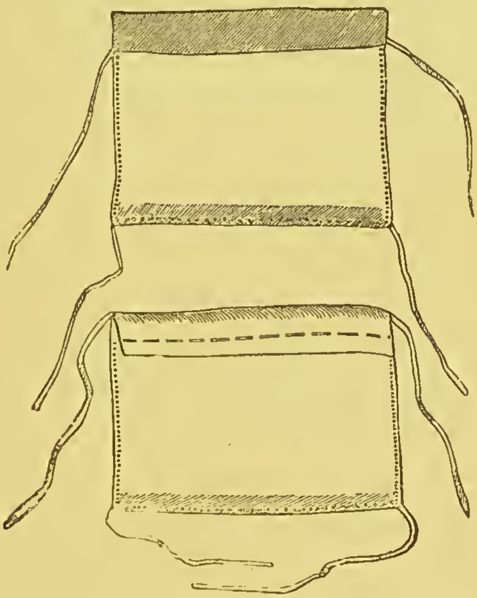

Fig. 27.—The upper figure represents the bag empty; the lower one the bag filled and sewn up.

irritated organs themselves. If we apply the poultice directly to the skin it must be allowed to become tolerably cool before the patient can bear it, and thus half its advantage is lost. In order to relieve spasm, as in colic—intestinal, biliary, or renal; to relieve inflammation of the pleura, the lungs, the liver, or other organs, we want to apply the poultice as hot as possible, while we protect the skin from being scalded.

In order to do this, a flannel bag should be prepared, a convenient size being twelve inches by eight; this should be closed at three edges and open at the fourth; one side of it should be about one

inch or one inch and a half longer than the other, as represented in the diagram, and it is convenient also to have four tapes attached at the points which form the corners when the bag is closed, in order to keep the poultice in position. Besides this, another strip of flannel should be prepared of the same breadth as the length of the bag, and long enough to wrap round it once or oftener. Crushed linseed, bowl, and spoon should then be got together, and the spoon and bowl thoroughly heated by means of boiling water; the poultice should then be made with perfectly boiling water, and rather soft. As soon as it is ready, it should be poured into the bag, previously warmed by holding it before the fire; the flap which is formed by the longest side of the bag should now be turned down and fastened in its place by a few long stitches with a needle and thread, it should then be quickly wrapped in the strip of flannel (also previously warmed), and fastened *in situ*, if necessary, by means of the tapes. It may be covered outside with a sheet of cotton wool. In this way the poultice may be applied boiling hot to the skin without burning; the two layers of flannel which are at first dry allow the heat to pass very gradually indeed to the skin; as the moisture of the poultice soaks through them, they become better conductors, and the heat passes more quickly, but the increase is so gradual as not to cause any painful sensations whatever, but only one of soothing and comfort. The poultice also naturally keeps much longer hot, and the necessity for changing it arises much less frequently.

The difference between the effect of a poultice made in the ordinary way, and in the manner just described, is sometimes exceedingly striking. It is, perhaps, less marked in cases of inflammation than in those of spasm. I have seen a patient suffering from intense abdominal pain at once relieved by a poultice made in the way just described, although a succession of poultices made in the ordinary way had been utterly useless. This way of making poultices is one of the minutiæ of medical practice; apparently extremely trivial, but really, I believe, very important. The relief which I have seen afforded by poultices made in this way, and the knowledge that *some* practitioners at least are ignorant of the method, must be my apology for drawing attention to such a trivial detail.

ON THE ACTION OF TONICS.

(' *The Practitioner,*' VOL. XXI., *August,* 1878.)

DURING the heat of summer many people feel limp and weak, and are disposed to sympathise, in imagination, with a collar which has just been washed, but not starched. They apply to their doctor for a tonic, take the medicine which he prescribes, and feel themselves much the better for it. There can be no doubt that the word "tonic" conveys a certain meaning both to doctor and patient, definite enough in one way, but very vague in another. Both understand that the tonic will increase the strength, and remove the weariness and languor, but how it does so probably neither has attempted to find out. On turning to Pereira we find that tonics are defined as agents which increase the tone of the system: but if we inquire further what is meant by tone, and what by the system, it will not be quite so easy to give a definite answer. Perhaps the easiest way of doing this is to take the want of tone, as we term it, for which tonics are administered, and to analyse the various symptoms which we find. First of all, then, there is a feeling of languor and disinclination to exertion, mental or bodily. The person may be roused by some excitement to make considerable exertions, but these are succeeded by a greater than usual feeling of fatigue; the appetite is generally diminished, the pulse is softer and more compressible than usual. Not unfrequently, too, there is less power than usual to resist the attack of disease. Want of tone, then, consists in diminished functional activity of the muscular, nervous, circulatory, and digestive systems, and a tonic is something which will increase this activity. Some tonics, however, act more on one system than another: and so we have vascular tonics, nervous tonics, and digestive tonics; as well as general tonics which seem to influence all the systems together. The functional activity of the body, and of the various organs which

compose it, depends upon the combustion which goes on in it and in them, and this combustion may be increased by increasing the nutriment, by quickening oxidation, or by removing more quickly than usual the products of waste, just as a fire may be made to burn more brightly by heaping on coal, by using the bellows, or by raking out the ashes. We may increase the functional activity of the body to a certain extent by increasing the food which a person takes, although there are limits to this, and an excessive quantity of food may prove injurious, just as one may smother a fire by heaping on too much fuel. The first class of tonics, gastric or digestive tonics, enable the patient to take more food, and with a greater relish. The most typical examples of this class are the so-called bitter tonics, such as calumba, quassia, gentian, cascarilla, and hops, either alone or in the form of bitter beer. In the mouth, these drugs produce a transient bitter taste, and increase the secretion of saliva. Thus they will tend to aid the digestion of starchy matters. In the stomach they cause a slight irritation, and the stomach, not having the same power of discriminating sensations that the mouth has, feels this, not as bitterness, but as appetite; unless the dose of the bitter should be too great, or too concentrated, and then it is felt as nausea, and is followed by vomiting. The appetite, however, which small doses excite, induces the patient to take more food, and to take it with greater relish. The increased relish is not to be disregarded. It would not be the same thing if the patient were simply to cram down, against his inclination, the same amount of food which he takes after his appetite has been excited by a tonic. We have not yet succeeded by pharmacological experiment in ascertaining precisely the effect of different emotions upon the stomach, but there can be little doubt that the pleasant feeling resulting from gratified appetite, aids digestion, while that of disgust and satiety interferes with it. Experiment has not shown that bitters increase the secretion of gastric juice in the same way that they do that of saliva, but they have an important action in lessening the tendency to putrefaction in the stomach. It is not impossible that in this way they prevent the formation during digestion of such substances as butyric acid, which is a direct nervous poison, and which, when absorbed into the circulation, would of itself tend to cause weakness and debility. It must not be forgotten that a man may be poisoned by substances formed in his own intestines, as well as by poisons taken into them by the mouth.

We all greatly dread the inhalation of sewer-gas into the lungs, but probably very few of us think that noxious gases formed in the stomach and intestines are readily absorbed by the blood, sometimes producing very serious results, and probably in many other cases leading to weakness and depression, the cause of which is never suspceted. Experiment has shown that bitters, if they do not inerease the seeretion of gastrie juiee, at least tend to diminish the seeretion of mueus, and lessen in this way, as well as by the antiseptie action just mentioned, the fermentation which mueus is apt to set up. It has been found by Köhler that even simple bitters in large doses will raise the blood-pressure by acting on the vaso-motor centre. It is doubtful whether they do so in the small doses usually administered or not, but there are other remedies—so-called vaseular tonies—whieh eombine this action to a eonsiderable extent with one upon the stomach. Thus, infusion of digitalis does not greatly increase the secretion of saliva, nor produee a feeling of appetite in the stomach. It acts, after its absorption, upon the vaso-motor eentre and upon the heart, rendering the cardiac pulsations slower, and more powerful by eontracting the vessels, and thus making the pulse firmer and less eompressible. This improvement in the cireulation makes itself felt in every organ of the body. Thus the stomaeh is relieved of eongestion, digests the food more easily, is less liable to seerete mueus, and is much less apt to be distended by flatulence. This is perhaps best marked in cases of mitral disease, where the venous congestion which accompanies such a eondition often leads to an accumulation of flatus, sometimes termed by patients heart-wind. The pathology of this condition has not been precisely made out, but we must not forget that interchange of gases goes on between the blood in the capillaries of the stomach and the gas contained in its cavity in the same way, though to a much less extent, as between the blood in the capillaries of the lung and the air contained in the pulmonary alveoli. The action of another drug, very different from digitalis, namely, charcoal, upon flatus of the stomach, is very marked, an l is usually ascribed in text-books to the power which the charcoal possesses of absorbing gas. But ehareoal only does this when it is dry; it loses its power when moist, and it seems incredible that a teaspoonful of chareoal swallowed after a meal and mixed with the contents of the stomaeh, including perhaps a pint of beer, in addition to all the gastric juice, should, after being churned up with the food in the stomach, absorb so

much gas as to have any effect whatever upon the flatulent distention. It seems much more probable that its action is simply mechanical, and that by the small insoluble particles acting upon the mucous membrane, the circulation through it is so stimulated that the blood, flowing more rapidly through the vessels, absorbs and carries away a part at least of the accumulated gases. In respect, then, of its action upon the circulation in the stomach, charcoal may have some similarity to digitalis, but here the similarity ends. Charcoal has no action upon the heart. It cannot restore the balance of the circulation like digitalis, and it has none of the general effects upon the heart and vessels produced by the friction in the wet sheet so well described by Dr. Winternitz.

The improved circulation produced by vascular tonics makes itself felt in the liver and intestines as well as in the stomach. The yellow tinge, indicating biliary congestion, will disappear from the eye, and hæmorrhoidal engorgement will be lessened or removed. The brain and nervous centres, under the influence of a freer current of blood, act more readily and powerfully, thought comes with less effort, and exertion, both mental and bodily, can be continued for a much longer time, without any sense of fatigue. Two conditions also disappear, which, although apparently contradictory, afflict debilitated persons at the same time. These are drowsiness and sleeplessness. Frequently do we hear debilitated patients complain that they are so heavy for sleep that when sitting in their chairs or going about their work an irresistible drowsiness comes over them, and they fall asleep in the midst of an unfinished task, but when they lay their heads on the pillow and seek rest the conditions are at once reversed, drowsiness disappears, they toss about from side to side in the vain attempt to fall asleep, and perhaps it is not until they get up and walk about for a little that they are able to effect their purpose. Both of these conditions, apparently so dissimilar, depend upon the atonic condition of the vessels, so that instead of resisting the pressure of blood within them, they yield before it. In consequence of this the blood gravitates, while they are in an upright position, to the vessels of the abdomen and legs, leaving the brain anæmic and thus inducing sleep. On the other hand, when the horizontal position of the patient allows the blood to flow more easily to the head, the carotids and their branches, instead of contracting and keeping back the blood, allow it to circulate rapidly through the brain, and thus the unfortunate patient, unable to think at the time

when he wishes to, is plagued by a rapid and incessant flow of ideas at the very moment when he least desires them. By giving digitalis so as to excite the vaso-motor centre the vessels are made to contract moderately, they no longer yield to the pressure of the blood, and thus the blood is prevented from gravitating to the abdomen and lower limbs, and a free circulation through the brain enables it to discharge its functions satisfactorily, notwithstanding the force of gravity which in the upright position always tends to make it anæmic. Again, when the patient retires to rest, the blood, which tends in a horizontal posture to rush towards the brain, is checked in its course by the carotids and their branches, which under the influence of the vaso-motor centre, stimulated by the vascular tonic, contract and regulate the cerebral circulation so as to allow only sufficient blood to pass to the brain for the purpose of nutrition, but not enough for functional activity.

It seems highly probable that a similar action is exerted upon the vessels of the spinal cord, and that thus the patient feels increased muscular power and is equal to more prolonged exertion.[1] But this is not all, for the subcutaneous cellular tissue, and probably also the muscles themselves, are also benefited by the improved circulation. In the case of the subcutaneous tissue, the improvement is visible and palpable, as it is also in the muscles, though perhaps rather less plainly. In persons suffering from debility, even although there be no cardiac disorder, we find the feet swollen at night, so that the patients complain of their boots being too tight, and the ankles may be seen to pit upon pressure. Under the action of vascular tonics this condition will disappear, the ankles no longer swell, and deep and continuous pressure produces little or no mark upon the skin. The muscles, too, which were previously soft and flabby, seem to undergo a similar change, and become firmer, harder, and more elastic. The mode in which this is effected seems to be twofold—less fluid is poured out from the vessels into the tissues, and more is absorbed from the tissues into them. Thus, instead of plasma stagnating in the intercellular places of the muscles and connective tissue, a brisk circulation is kept up, by which fresh oxygen is

[1] For a fuller explanation of the *modus operandi* of contraction of vessels in the cord in increasing muscular strength, we may refer to a paper on the curative effects of mild and continued counter-irritation of the back in cases of general nervous debility and in certain cases of spinal irritation, by Arthur Gamgee, M.D., F.R.S., in the *Practitioner*, vol. xviii. p. 113.

supplied, and the products of waste are removed. The tissues are thus put into the most favourable eondition for performing their functions, for, as we have already stated, functional activity depends upon the rapidity of eombustion which goes on within the tissues or organs. It is quite possible to paralyse a muscle by stopping the supply of blood to it, and thus preventing it from obtaining oxygen, but it is still easier to paralyse the muscle by allowing the produets of its own waste to aeeumulate within it. The easiest way to stop eombustion in the musele is, so to speak, to smother it in its own ash. It has been shown by Kroneeker that if we remove the produets of waste from a muscle whieh has been kept in a state of tetanus until it refuses to eontract any longer, we can restore its eontractile power even although we supply no fresh oxygen to it. In all probability it is the aeeumulation of the produets of waste in the muscles in debilitated persons, whieh is, to some extent at least, the cause of the languor whieh they feel. That such is the faet, is, I think, shown by the feeling of comfort whieh they experienee when the legs are gently shampooed, the pressure being always exerted upwards so as to favour the return of the fluids from the tissues. Such a proeedure tends to give a lightness and eorkiness to the limbs, which ean hardly be attributed to any ehange in the nervous system generally, but must rather be aseribed to the removal from the museles of those waste products whieh were partially paralysing them.

In talking of the nervous system, of the brain, and of the spinal eord, we have not taken into aeeount this action of vaseular tonies inereasing eombustion and removing waste from the nervous tissue, but probably, although we eannot see it so readily as in the eonneetive tissue and museles, the same proeess goes on in the nervous eentres, and has much to do with the benefieial aetion of tonie remedies. I have stated that the aetion of tonics upon the intereellular fluid in the tissues is probably twofold—that they prevent excessive exudation from the vessels at the same time that they produee increased absorption. The reasons for believing that they lessen the exudation of fluid from the vessels are derived from a consideration of tho pathology of œdema as made out by Ranvier. The first experiments upon the subject of œdema were made by Lower, who, in 1680, tied the vena cava, and found that œdema appeared in the lower extremities. A similar eondition was noticed by Bouillaud in patients suffering from thrombosis of the iliae veins, and thus it appeared clear that the occurrence of

œdema was due to the absorption of the intercellular fluid being prevented by venous congestion. Lower's experiments, however, were repeated by Valsalva, Hewson, and others, without producing œdema, and the cause of its production therefore remained obscure. It was reserved for Ranvier to clear up this question, and to show that the occurrence of œdema usually depended upon increased exudation from the vessels as well as diminished absorption by the veins. He tied the vena cava in the abdomen of a dog, and found, like Valsalva, that œdema did not come on. The quantity of fluid exuding from the arteries was so small that the lymphatics were able to absorb it without any assistance from the veins, and thus it did not accumulate in the tissues, but on cutting the sciatic nerve on one side, intense œdema occurred in the corresponding leg. Venous congestion was equally present in both legs as the vena cava itself had been tied, but in one the nervous influence proceeding to the arteries through the sciatic nerve kept them contracted and prevented the exudation of more fluid than the lymphatics could absorb. In the other leg, however, where the nerve had been paralysed by a division, the vessels dilated, the limb became rosy and warm, and so much fluid was poured out that the lymphatics alone could not absorb it without the aid of the veins. Ranvier next proved that this dilatation of the arteries was due to paralysis of the vaso-motor and not of the motor fibres contained in the sciatic, by cutting, in different experiments, the motor and the vaso-motor nerves in the lumbar region before they had united to form the nervous trunk. When the motor strands were divided, as they issued from the lumbar vertebræ before they had been joined by the sympathetic fibres, complete paralysis of the leg was produced but no œdema occurred; but if, on the other hand, he divided the sympathetic fibres, passing to the sacral plexus, there was no motor paralysis—the animal could still use its limb, but the vessels dilated and œdema occurred.

These experiments show pretty conclusively that dilatation of the vessels by paralysis of the vaso-motor nerves is one factor in the production of œdema. In them, of course, we see in an exaggerated condition the same phenomena which are observed in cases of debility, because in these experiments the vaso-motor nerves were completely paralysed, whereas in our patients they are simply weakened. We may sometimes see very clearly in persons whose vascular system is deficient in tone, the effect of dilated vessels in causing œdema even when there is no great

obstruction to the return of blood. Such persons, when walking about in a warm day, with their arms hanging by their sides, sometimes find their hands become so swollen that they can hardly close their fists. The combined effect of heat and exercise upon their already debilitated vascular system, aided by the effect of gravitation, has caused so much fluid to escape into the tissues of their hands, that the veins and lymphatics are together unable to absorb it, and thus the fingers become swollen. The absorption of fluid from the tissues is, like its exudation into them, greatly controlled by the central nervous system. This is shown by some experiments of Goltz and Nasse. The former found that when a fluid was injected under the skin of the back of a frog, it was rapidly absorbed so long as the brain and spinal cord were uninjured, but when they were destroyed, little or no absorption took place. As the ordinary action of the nerve-centres causes absorption to go on, we would naturally expect that any increase in their activity would quicken the absorptive process, and this indeed was actually shown by Nasse to occur. It is well known that irritation of a sensory nerve stimulates the vaso-motor centre reflexly, and causes the vessels to contract. But, in addition to this action, Nasse found that irritation of a sensory nerve also caused increased absorption. It has not yet, so far as I know, been proved experimentally that such a drug as digitalis, which undoubtedly stimulates the vaso-motor centres, has a similar action to stimulation of that centre by irritation of a sensory nerve. Some time ago I made a few experiments upon this subject, but from imperfect graduation of the dose, the results I obtained were unsatisfactory, as the heart was too much affected by the drug, and the circulation became entirely arrested. There seems, however, no reason to believe that direct stimulation of the vaso-motor centre by digitalis will have a different action from its reflex stimulation through a sensory nerve, and we may therefore, I think, confidently assume that vascular tonics like digitalis increase the absorption of fluid from the tissues. They will thus remove the products of waste, and by keeping up a constant circulation of fresh intercellular fluid will assist combustion and functional activity in the tissues.

Another most valuable tonic, strychnia, has an action even more widely extended over the body than digitalis. It is at once a gastric, vascular, and nervous tonic. It aids digestion like other simple bitters in the way already described. It has, with the

exception of quinine, a more powerful action than most other bitters in preventing putrefaction. It excites the sensibility of the vaso-motor centre, thus exerting a beneficial effect upon the circulation, and likewise directly stimulates the nervous tissue of the spinal cord itself. So great is its effect upon the vaso-motor centre that by its means physiologists have discovered that instead of being confined to the medulla oblongata, as was formerly imagined, this centre extends down the spinal cord. It has just been said that an impression made upon the sensory nerves, reflexly stimulates the vaso-motor centre, contracting the vessels and raising the blood-pressure, but when a cut is made across the spinal cord just below the medulla oblongata this result is not produced. From this experiment it has been concluded that the vaso-motor centre was entirely confined to the medulla oblongata above the place of section; but if a little strychnia be now injected into the veins of an animal in which the cord has been thus divided, and a sensory nerve be then irritated, the vessels will contract and the pressure of the blood will rise. It thus becomes evident that the vaso-motor centre extends down the cord from the medulla, although its spinal portion is so feebly developed that under ordinary circumstances it has no power to contract the vessels when reflexly excited by stimulation of the sensory nerve. But strychnia has the power to increase its excitability so much, that reflex stimulation in this way will produce through it a decided effect. Now when we consider that sensory impulses are proceeding every moment from the skin to the vaso-motor centre, we can readily perceive how a slight increase in susceptibility produced by strychnia will have a wonderful effect in raising the tone of the vessels, and aiding the circulation. The mode in which quinine acts is not so clear, but we know from observation, that it also, in small doses, renders the pulse stronger and less compressible.

We have now seen how tonics may increase the quantity of nutriment taken into the body generally, how by their action on the vessels they quicken the circulation of inter-cellular fluid in the tissues, and by thus aiding its oxidation, and removing the products of waste, they greatly increase the functional activity of the various organs of the body.

We have now to consider how they affect the removal of waste from the body generally. The inter-cellular fluid in which these products are contained is absorbed into the general circulation

by the veins and lymphatics. Unless some provision were made for its removal, it would soon accumulate in the blood and arrest the functional activity of the various tissues, beginning with the most susceptible of all, the nervous tissue, and causing death. But these substances in all probability undergo further oxidation in the blood after their absorption and before they are finally excreted. This oxidation will be assisted if the respiratory movements by which oxygen is taken into the lungs are rendered deeper and more frequent, and also if the blood itself should acquire greater power to absorb this oxygen. Now strychnia has an action upon the respiratory centre in the medulla oblongata similar to that which it exerts upon the vaso-motor centre, and under its action respiratory movements become both quicker and deeper. No such effect is produced on the medulla by such a tonic as iron, but under the influence of this remedy the blood corpuscles not only become greatly increased in number, as was shown by Dr. Gowers in a paper in the *Practitioner*, vol. xx. p. 1, but they also contain a greater amount of hæmoglobin. Oxygen is thus more rapidly carried from the lungs to the tissues, and the process of combustion can thus go on more readily, both in the tissues themselves and in the minute blood-vessels into which the products of waste have been absorbed.

The rise in blood-pressure which occurs under the influence of tonics not only affords, as we have just seen, the most favourable conditions for oxidation in the tissues and for the removal of the products of waste from them, but it also assists in their elimination from the body itself. It has been shown by Ludwig and his scholars that the secretion of urine is, generally speaking, proportional to the pressure of blood in the renal glomeruli, and thus the pressure would rise along with the tension in the vascular system generally. The contraction of the vessels which tonics produce will therefore raise the tension in the kidney as well as in other parts of the body, and thus aid in the elimination of the products of waste.

From what has just been said, then, it would appear that strychnia or nux vomica is one of the most valuable tonics which we possess. When combined with nitro-hydro-chloric acid it is perhaps one of the most efficient remedies that we can give for the debility which is so often noticed in warm weather, and when the ordinary tonics, such as gentian, calumba, cascarilla, or quinine do not produce the desired results, the addition of a little nux vomica or strychnia to them may give us the wished-for effect.

ON THE ACTION OF ALTERATIVES.

(*'The Practitioner' for September* 1876.)

If we were to take the word alterative in its widest sense, it would embrace all the medicines we employ; for all of them are used for the purpose of producing some alteration or other in the bodies of those to whom they are administered. Nor is the alteration confined to them alone; it may also influence their offspring, and Buchheim very truly says that we are quite justified in calculating what the influence of a purgative, which we take to-day, will be upon the bodily and mental well-being of our great-grandchildren. I know a lady who believes that ill-temper in children is due to illness, and whenever any one of her own family was naughty during their childhood, she invariably administered a dose of Gregory's mixture to the offender. The practice was most successful, mind and body were purged together, the ill-temper fled with the evacuation of the bowels, and a wholesome dread lest the dose should be repeated co-operated with its physical action to prevent a return of the naughty fit. Who shall say that the temper and disposition as well as the bodily health of this lady's children and grandchildren are not altered for the better by her judicious use of rhubarb and magnesia, and who shall deny to Gregory's mixture an honourable place among the alteratives? And yet if we saw its name appearing in a list of them we would be very apt to say that it was like Saul among the prophets—it had a perfect right to be there, but it would have been better elsewhere—Epsom salts, jalap, and other purgatives being more suitable companions for it than iodide of potassium, arsenic, and the other remedies to which we usually give the name of alteratives. For custom has now excluded from this class all medicines which give external signs of vigorous action by purgation, sweating, or diuresis, and has restricted the term to such remedies as do their work slowly

and secretly but none the less effectually. In short, we use the word alteratives very much as a cloak for our ignorance. For example, a patient comes to us complaining of more or less constant headache just above the eyebrows. We generally associate such frontal headache with disturbances in the digestive apparatus, and we accordingly at once inquire into the condition of the tongue, appetite, and bowels. We find that the tongue is fairly clean, the appetite fairly good, but the bowels are constipated. We give a drachm of sulphate of magnesia three times a day, get the bowels to act properly, and in four cases out of five the headache disappears. But in the fifth case it remains, although the constipation has been removed and the evacuations are free. We order the medicine to be continued, but in addition give a calomel and rhubarb, or a blue pill at night, and now we obtain the desired effect. The sulphate of magnesia alone was unable to remove the cause of the headache, but the mercury seems to touch the right spot and put things in proper order again, so that no farther pain may be experienced for a good while to come.

What the probable reason of this is I will mention by and by, but at present I wish to contrast the action of these two remedies with that of a third.

Suppose, then, that we see, as we very often do, a patient complaining of pain above the eyebrows but with all the functions of the alimentary canal apparently in good order. These cases are frequently met with amongst girls from fourteen to twenty. The tongue is fairly clean and moist, although it may be slightly marked with the teeth at the edges, there is no complaint of wind in the stomach, there may be no pain after eating, and the bowels may be quite regular. We order them ten minims of dilute nitro-hydrochloric acid before meals and the pain disappears, just as it did in the other cases after salts or calomel. But here we have no sign of action produced by our remedy except the disappearance of the patient's complaint. There is no purgation by which to explain the results: we cannot say that the morbid matter which caused the pain has been forcibly removed from the alimentary canal or from the blood. Our remedy has corrected the nutrition of the body in some mysterious and secret way, as mysterious and secret as the manner in which a hearty meal sustains the nutrition, and we class our medicine among the alteratives just as we class the substances composing the meal among the nutritives.

Or let us take another example. The skin, which ought to be soft and uniform in colour and smooth on the surface, becomes covered with round reddish spots, on which the epidermis accumulates, giving them a somewhat silvery hue, and from which it falls in scales. We give arsenic internally, and even without the use of any local application to the skin, although these are undoubtedly useful, we may find the scales fall off, the reddened spots disappear and the skin assume its normal appearance.

Here again our medicine acts in the same slow, secret way, causing the skin once more to return to its proper healthy mode of nutrition, or, in other words, causing the cells which compose it to take up, assimilate, and use in the proper way the nutritive, materials brought to it.

Now I find the question, How do alteratives act? to be an extremely difficult one; and I do not feel at all certain that I shall be able to give the correct answer to it. But the difficulty of the question is not merely personal—it has been felt by every writer of a textbook on Materia Medica; and on looking through the standard works on the subject I see that an explanation of the mode of action of alteratives is rarely or never attempted.

I have, therefore, less delicacy in bringing the subject under notice, as my attempt to explain their action, even though incorrectly, may, by awaking criticism, and directing general thought to this question, lead some to a better solution of it than the one at which I have arrived.

We have already seen that there is a striking resemblance between nutritives and alteratives in the quietness with which they effect their purpose; and I believe that it will greatly assist our comprehension of the mode of action of those remedies which alter nutrition if we first take a glance at the way in which nutrition is normally maintained. A railway navvy, working with pickaxe, shovel, and barrow, striking hard into the firm earth or the solid rock, lifting heavy weights and wheeling heavy loads, violently exerting every muscle in his body and perspiring at every pore, would soon exhaust both his muscles and glands, if he were to abstain entirely from food and drink, and not replace the solid matter and liquids which he is continually losing while at work. He would get thinner and weaker, and would quickly die; while if he has an abundant supply of bread and butter, beefsteak and salt, with as much water as he wants, he may go on working day after day, week after week, and month after month, without his

strength undergoing the least diminution or his body becoming lighter by even a single ounce. It may be remarked that I have put salt here in the list of foods, and I draw special attention to it, because the quantity of it which we use is so much less than that of the other sorts of food that we are apt to forget it. And all the more so because we get it added to our bread by the baker, or to our butter by the dairyman, or get it thrown on our beefsteak while it is cooking, and thus forget that we may take a good deal during the day although we never put a particle of it on our plates during meals. And yet the simple experiment which we find in every boy's book of chemical tricks, of telling into which basin of water a hand has been put by the turbidity which occurs on testing it with nitrate of silver, shows how constantly we are losing salt from the skin; and if we put our tongue to our hand after we have been perspiring freely, the taste will convince us that the quantity of salt we lose by the skin is not inconsiderable, even if we were to leave out of account the much greater loss which takes place by the urine. We find no difficulty in understanding how the salt lost by the various emunctories is replaced by that which we take into our stomach. For salt dissolves readily in water, and when in a state of solution it diffuses easily through animal membranes. Thus when it is taken into the stomach it is soon dissolved by the liquids it finds there, is absorbed into the blood-vessels, and travels with the blood to all parts of the body.

But with regard to the bread, butter, and beefsteak the matter is not so easy. It is true that fats may be made to pass through animal membranes, but not very easily, and the difficulty is greater when the membranes are moist, as they are in the body. Starch, of which the bread is composed, and albuminous substances, such as those of the beefsteak, hardly pass at all, and in order to be made available for the wants of the body, they must first be rendered soluble. Nor is this all. In order to render them soluble they must undergo a chemical change, the starch of the bread being converted into grape sugar, the myosin of the beef-steak into soluble albumen and peptones, and the butter being partially split up into fatty acids and glycerine. Now all these changes can be effected by the chemist in his laboratory, or by the manufacturer in his factory, but both of them require to use much force in the shape of heat to pull apart the atoms of the starch, albumen, or fat, and allow them to enter into new combinations. Thus starch is converted commercially into grape sugar by boiling

it with sulphuric acid; albumen into peptone, not by simply boiling it, but by boiling it under pressure in a Papin's digester with dilute hydrochloric acid; and fat is split up into fatty acid and glycerine by treating it with superheated steam. But the processes which require so much expenditure of heat—heat which might drive a railway-engine or a steam-hammer—are all carried on within the body at a gentle temperature by means of certain ferments. These ferments possess the wonderful power of doing, without any apparent effort, the same work of decomposing bodies, as only a considerable heat could do without them. In fact we might compare them to such things as nitro-glycerine, of which a small quantity will shiver into fragments a solid rock on which many and heavy blows of a powerful steam-hammer would have made but a slight impression. The ferments in the alimentary canal are pepsine, the pancreatic ferments, and the ferments of the intestinal juice. Pepsine differs from the other two in only acting in an acid solution, while the others act in neutral or alkaline ones, and this I consider to be a very important difference indeed, as you will presently see.

Although these ferments split up starch and albumen with such force, they do not seem to be used up in doing so, and a very small quantity of ferment will go on for a long time without seeming to be exhausted by its work. Now no manufacturer would ever think of throwing away anything with such valuable properties as this, and yet we used to imagine that nature improvidently threw them away, and allowed them to be excreted by the fæces. Some time ago, however, it was found by Brücke that the whole of the pepsine was not voided in this way, for part of it was absorbed, and could be detected in the muscles and in the urine. Von Wittich also found a ferment in the liver and bile, which, like that of the pancreas, would convert starch or glycogen into sugar; and Hüfner found ferments which also possessed, like that of the pancreas, the double power of digesting fibrine, and converting starch into sugar in the lungs. From these facts I ventured some time ago, in a paper on the Action of Purgative Medicines, which I published in the *Practitioner*, to advance the hypothesis that the digestive ferments were reabsorbed from the intestinal canal, and being again carried by the blood to their respective glands, did duty over and over again. For if bile is either injected into the intestine or injected under the skin, it passes to the liver and is excreted by it; urea injected into the blood goes to the kidneys, and thus it

seems probable that pepsine, like these substances, will find the way to its own peculiar secreting organ, the stomach; and pancreatine to the pancreas.

But if this notion be correct, there must be pepsine and pancreatine very constantly in the blood.[1] Now this will not matter very much in the case of pepsine, because it will only act in acid solutions; but the case is different with pancreatine, which acts in neutral and alkaline solutions, and there seems to be nothing to prevent it from acting on the muscles and other albuminous tissues.

And, indeed, when we come to think of it, how can the albuminous substances of the body be split up and consumed, excepting by the aid of ferments? If we lay a piece of raw meat on the fire, it does not burn readily, and the fire must be pretty hot to consume it entirely; and yet, for my own part, I used to accept it as a fact, that the albuminous substances of the body were oxidised into urea and carbonic acid, without ever thinking how this combustion was effected. But, as we have seen that these ferments possess the same disintegrating power as heat, and as we have seen, moreover, that they have been found in various tissues of the body, I think we may assume that they are the means by which the tissues become broken up and finally oxidised.

According to this view, then, the whole process of nutrition is carried on by means of ferments. Through their agency the food is rendered soluble, so as to be fitted for building up the tissues, and by their agency, too, the tissues themselves are also, although more slowly, broken down. It is obvious, then, that any alteration in the quantity or quality of the ferments in the intestine or blood will greatly influence nutrition, and this brings us to the question, How do alteratives act?

And, first of all, we will consider the action of such alteratives as not improbably act upon the ferments in the intestine. I have already alluded to the similarity between the effects of nitrohydrochloric acid and sulphate of magnesia, either with or without a blue pill. Now sulphate of magnesia excites a copious secretion, washes out the intestine, and carries away some of the bile also. But it has probably much less effect upon the duodenum than mercury has, and thus does not greatly hinder bile, which has been thrown by the liver into that part of the intestinal canal, from

[1] When this paper was written little was known regarding the possible reconversion of ferments into zymogens. D'Arcy Power and I have found pancreatine in the urine. (*St. Bartholomew's Hospital Reports*, 1877, vol. xiii. p. 300.)

being reabsorbed. Mercury, on the other hand, probably excites the duodenum to active peristaltic motions, the bile is hurried downwards and washed out, without any time being allowed for reabsorption. Now, according to my supposition, the ferments contained in the duodenum will share the fate of the bile—they will be swept out of the body in the fæcal evacuations, and consequently the quantity in the blood will be diminished. The tissue change which these produce in the body will also be lessened, and thus we can see how purgatives, and especially mercurial and saline purgatives combined, may be useful at the commencement of a fever.

We can also see how people may readily catch cold after the use of purgatives, and how these remedies are specially depressing to old people, whose heat-producing powers are already low, and who probably have difficulty in again forming new ferments to replace those they have lost.

It is not easy to say precisely in what way nitrohydrochloric acid will affect the ferments in the duodenum and liver, but that it does do so is, I think, shown both by its effect in frontal headache, without either dyspepsia or yellowness of the skin, or conjunctiva, and by its use in oxaluria.

In an interesting paper published in Vol. II. of the St. Bartholomew Hospital Reports, Dr. Dyce Duckworth showed that the urine of patients, presenting no other symptoms than a tongue fissured longitudinally, and great depression of spirits, was generally found on examination to present the white hummocky cloud characteristic of oxalate of lime, and on microscopic examination to display numerous crystals of this substance. The oxalate of lime, in such cases, frequently alternates with a sediment of urates. Under the use of nitrohydrochloric acid, the patients recover their spirits, and the oxalate of lime disappears.

Now the alternation of lithates with oxalates is, I think, very suggestive, and points to the liver as the part affected. For it would appear that it is to a great extent in the liver that such albuminous matters as are to be used up at once, and are not to form permanent tissue, are broken up. Thus a meal of beefsteak alone will yield, in the liver of a dog, glycogen, and nitrogenous bodies which usually are converted into urea, but which, if imperfectly oxidized, will probably appear as urates. Now if the albumen is split up too quickly, as it would be by too much ferment in the liver, we would naturally expect the products of decomposition

to be less thoroughly oxidized than they would otherwise be, and according as one or other took the available oxygen, so would be the waste product. If the glycogen got the oxygen, the nitrogenous products would be imperfectly oxidized, and lithates would appear; if the nitrogenous products got the oxygen, the glycogen would be more or less deprived of it, and thus, instead of undergoing complete combustion into carbonic acid and water, sugar might appear in the urine, or products of imperfect combustion, such as oxalic acid, might be formed. Lithates appear in the urine after a heavy dinner with wine, or some other cause of digestive disturbance, whereby we may suppose the decomposition of albuminous matter in the liver to be increased, and they also appear after violent bodily exercise, which will increase the decomposition of albumen in the muscles.

It would be a matter of much interest to observe whether nitrohydrochloric acid lessens the urates in the second case, though undoubtedly it would be a work of considerable difficulty. For my own part I am inclined to think that nitrohydrochloric acid acts chiefly in the intestine and liver, and slightly, if at all, in the tissues.

There are other alteratives which have little or no action in the intestine, but have a powerful influence upon the tissues generally. They *may* have an action, and very often have one, upon the changes which go on in the liver, but they do not all have it.

Let us now take a glance at some of these alteratives more particularly; and as time will not permit me to enter into a lengthened discussion of the mode of action of each, I will content myself with a few remarks. The use of potash is seen *par excellence* in gout, not merely as a remedy, but as a prophylactic. A very gouty old gentleman told me that by two methods he had succeeded in warding off an attack for a long time. The first of these was to drink a large quantity of water early in the morning. "Too little water," said he, "is a great cause of gout; and whenever you get gouty patients in the upper classes, always ask them how much water they drink. You will generally find that they tell you, We take a small cup of tea in the morning, and a small cup of coffee at night; and this is all the water they take, except what they get in the shape of wine and beer, or brandy and soda. Water, pure and simple, many of them never touch; in such persons gout may often be warded off by simply

washing out their tissues. Give them a large draught of water the first thing in the morning, and make them take more water and less wine at meals.

"But if this is not enough, and the gout still threatens, give them 30 grains of bicarbonate of potash, and 20 of nitrate, in a large tumbler of water."

Now colchicum, as we all know, is useful in gout, and it used to be supposed that it was so by increasing the elimination of uric acid. But this is not the case, for Garrod and Parkes have shown that the elimination of uric acid is rather diminished by it. The explanation I would give of its action is that it affects the ferments by whose action the uric acid is formed, and thus by lessening its formation produces somewhat the same effect as increasing elimination. Iodide of potassium has a special action on the lymphatic system, and it is in affections of this system that we see its beneficial effects most clearly. For the fasciæ and other fibrous structures are nothing but lymphatic pumps, pumping up the waste material from the muscles and sending it on into the lymphatic trunks (p. 333).

It has been supposed that the action of iodides is owing to the chlorine already in the body having a stronger affinity for bases than iodine, and thus setting the iodide free. If this were the case we should expect that the effect of an iodide would be greater when much chlorine is present in the body; in this case the iodine would be more readily freed. The action of chloral is said by Liebreich to depend on the liberation of chloroform in the blood by the action of the alkalis contained in it, and when talking with him he told me that chloral was apt to lose its effect when given for a long time, unless the alkalinity of the blood was kept up by the administration of alkalis. It is possible that in the same way iodide of potassium may become less powerful, if we neglect to keep up the chlorides in the body, and that its action may be increased by the administration of common salt. It is only lately that this thought occurred to me, and I have not yet had an opportunity of testing it, but perhaps some here may already have done so.

In a case of epilepsy, however, I once tried common salt with complete success, the fits being entirely stopped. In the next one it had no effect. Since thinking over the subject of alteratives, it occurred to me that possibly the success in the first case was due to the previous administration of a bromide, but unfortunately

I have lost the notes of the case and cannot now ascertain if this were so or not.

Mercury seems to have as special an action on the albuminous tissues as iodides have on the lymphatics, and the breaking down of lymph by it in iritis seems more to resemble the digestion of fibrine by pepsine, or pancreatine, than anything in inorganic chemistry. This special affection of mercury and iodides for different structures may give us a key to the proper employment of these drugs singly or in combination. Are the albuminous tissues to be acted on ?—give mercury. Are the lymphatics to be set in action, either for the purpose of carrying away the albuminous *débris* resulting from the effect of mercury, or for the absorption of enlarged glands, or removal of pain, hardening, &c., connected with tendinous or aponeurotic structures ?—give iodine.

Time will not permit me to enter upon the actions of phosphorus, arsenic, and antimony, or to show the wonderful resemblance between them, and I would simply, before concluding, recapitulate one or two of the chief points in this paper, as it may assist the discussion upon it.

All medicines may be called alterative, but the name is specially applied to those which imperceptibly modify nutrition.

Nutrition is carried on in the intestine, and probably in the body, by means of ferments.

Alteratives probably modify nutrition by modifying the action of these ferments.

Nitrohydrochloric acid probably acts in headache, and also in the depression of spirits associated with oxaluria, by modifying the action of ferments in the intestine or liver.

Lithates are probably formed in the liver, and also in the muscles. The question arises—Is nitrohydrochloric acid useful only when the lithates arise from disorders of the liver and digestion; or is it also useful when the lithates arise from other causes ?

Colchicum is probably useful in gout, by diminishing the production of uric acid.

Iodide of potassium acts on the lymphatics.

Mercury acts on the albuminous solids.

Is the action of iodides or bromides increased by giving salt ?

INDIGESTION AS A CAUSE OF NERVOUS DEPRESSION.

('*The Practitioner*,' vol. xxv., October and November, 1880.)

To most men who are engaged in intellectual work, an autumn holiday has become a matter of necessity, and is not to be regarded as a mere luxury. During eleven months of the year many who are engaged in brain work systematically overtax themselves, trusting to the month's holiday to bring them again into proper working order. Formerly this was not the case. Men seemed to be able to go on, not only month after month, but year after year, without any vacation at all. The circumstances under which they lived were different from those which exist now. The very means which facilitate our holidays—the network of railway which puts us into complete and easy communication with any part of the Continent of Europe, or the quick ocean steamers which enable us to enjoy half of a six weeks' holiday on the other side of the Atlantic, as well as the telegraphic communications which will warn us in a moment, even at the most distant point of our travels, of any urgent necessity for immediate return—all these are the very means which increase our labour during the greater part of the year. We live at high pressure, letters and telegrams keep us constantly on the *qui vive*, express trains hurry us miles away from home in the morning and back again in the evening, and the pressure of competition is so great that few men can afford either to take their work easily or to modify the constant strain of it by breaks of a day or two at a time. Wearied and exhausted, the hard-worked man goes off for his autumn holiday and, if he can, will spend most of it in the open air, either yachting, walking by the sea-shore, strolling in the country, shooting on the moors, or climbing the Welsh hills or the Swiss mountains. After a month spent in any of these ways, the brain-worker comes back

to town feeling himself a different man. Instead of his work being a slavery to him, as it was before he started, he feels it to be a pleasure; he gets through it with ease, and feels not only that the amount he can accomplish is greatly increased, but that the quality is also improved. Perhaps for a short time after his return he is hardly in a condition to do brain-work at all. He sits down to his desk but feels cramped in the unaccustomed posture, and he would rather work off the superabundant energy within him by a long walk or a stiff climb, than restrain it with difficulty to the simple task of driving a quill. After a week or two he settles down and works steadily along with comfort and ease for a couple of months or more, when he again begins to sink below par. His apprehension is no longer so acute, his power of concentration is diminished, he can no longer fix his attention for any length of time upon one subject without a severe effort. His mental vision becomes less perspicuous, his ideas succeed each other more slowly, and find expression with greater difficulty, so that he communicates his thoughts with less fluency and less clearness than before. His temper, too, undergoes a change. Instead of regarding the daily occurrences of life with equanimity, and making the best of what cannot be helped; irritation so slight as to be unfelt at other times provokes him to anger or peevishness, and even when he possesses sufficient self-control to restrain his feelings and prevent them from being manifested outwardly, to the annoyance of his friends or neighbours, the very effort of restraint seems to increase the internal irritation, until at last it either explodes in an ebullition of wrath on some comparatively trivial circumstance, or tells upon the digestion and nervous functions of the individual himself, diminishing the appetite or causing intense muscular weariness. In others, again, we find that along with, or taking the place of, irritability there is great mental depression. Everything is looked at from a gloomy point of view, himself, his friends, and his surroundings. He does not feel equal to his work; nothing that he does pleases him; he is apt to become distrustful of himself and jealous of others; apt to think that his friends are slighting him, or to fancy that he has offended them. Even when all external circumstances leave nothing to be desired, the unfortunate victim cannot enjoy life. His mind is occupied with gloomy forebodings of miseries to come, or he becomes a prey to melancholy and depression without any apparent reason. This melancholy weighs most deeply upon him during the night, and if he happens to wake

in the small hours of the morning, as he not unfrequently does, life seems not worth living, but a burden of which he would willingly be quit. Melancholy is at times associated with sleeplessness, and then the two evils re-act upon and increase each other. For this causeless sorrow has a similar effect to that of real sorrow. As Shakespeare says:

> "Sorrow's weight doth heavier grow,
> Through debt that bankrupt sleep doth sorrow owe."

At other times, instead of sleeplessness there is an abnormal tendency to drowsiness, which sometimes comes on almost irresistibly at the very moment when some important work, requiring all the best powers of the intellect, has to be performed, and rendering its performance either imperfect or completely impossible. As soon as the person goes to bed he falls asleep, and sleeps like a log till morning, when he rises with difficulty, feeling almost more exhausted than when he went to bed the night before, with perhaps a little tightness or pain over the forehead, eyes, or temples. After breakfast he feels somewhat revived, and will work comfortably for a short time, but about one and a half or two hours after the meal weariness overtakes him, again passing off after it has lasted a variable time. During the day this is repeated, fits of more or less energy alternating with periods of languor and exhaustion. These languid fits may be noticed two or three hours after lunch or dinner, and the sufferer is not unfrequently tempted to have recourse to the decanter of sherry or the brandy-bottle, not only to obtain relief from the feeling of personal discomfort, but to supply the energy which he feels to be necessary to enable him to do the work he has in hand. But this is a ruinous course to adopt, for not only does it pave the way to habits of confirmed drunkenness, and leads to tissue changes which will ultimately abolish the functional activity of the most important organs of the body, and bring the individual to a premature grave; it enables him to do his work only imperfectly at the time. After an application to the decanter or bottle his powers may seem to himself to be as great or greater than usual, but this is to a considerable extent a subjective feeling only, as he will probably be able to discover by results.

Now how is it that such a change has come over the man in a few months, so that he seems to be a different individual from the one who returned, bright and lively, from his autumn holiday?

How is it that the even-tempered man has become irritable, the clear-headed man muddled, the active lazy, the sober perhaps a tippler, and the cheerful and buoyant depressed and melancholy; that the brain performs all its functions with difficulty, and the mind is so altered that it does not seem to be that of the same individual? And yet, after all, the man is the same, and the brain the same, at least in its essential structure, as it was a few months ago, and as it will be in a few months more, after another holiday has again put it in good working order. What has happened to it in the mean time to cause such a dreadful alteration? Not only does the brain seem exhausted, but the whole system appears to be languid and weak; instead of the man being able for a twenty or thirty miles walk, one of a mile or two will produce fatigue, and sometimes an intense languor is felt without any exertion at all. And yet all this time he may have been trying to keep up his strength. He takes butcher's meat three times a day, perhaps also strong soups, to say nothing of wine, or brandy and soda to pick him up. His tissues ought to be getting sufficient nourishment to enable them to do their work, and yet it is evident that they are not in a condition to do so. The man, and very likely his friends also, wonder at his condition, and when he goes to his medical attendant to describe his case he says, "I take all sorts of strengthening things, and yet I feel so weak." If, instead of using these words, he were to say "*Because* I take all sorts of strengthening things I feel so weak," he would express a part at least of the truth. He, and his friends who wonder with him, forget that all the functions of life are more or less processes of combustion, and that they are subject to laws similar to those which regulate the burning of the coal in our fireplaces. Two things are necessary for the combustion, fuel and oxygen; sometimes it is the fuel that fails, but not unfrequently it is the oxygen. Sometimes, no doubt, our fires go out because the fuel is quite exhausted, but this is very rarely the case. It is only under very exceptional circumstances that we find a fire burned away so completely as to leave nothing but ash. Almost invariably some fuel still remains—often, indeed, enough to make up a good fire when properly put together. If we sift the ashes from the grate we generally find a quantity of cinders, sufficient to make a fire, and these have ceased to burn because they were unprovided with oxygen, which was prevented from reaching them by the ashes with which they were covered.

The reason why our fires burn low, or go out altogether, either

is that we put on too much coal, or that we allow them to be smothered in ashes. It is the child who pokes the fire from the top to break the coal and make it burn faster; the wise man pokes it from below so as to rake out the ashes and allow free access of oxygen. And so it is with the functions of life, only that these being less understood, many a man acts in regard to them as the child does to the fire. The man thinks that his brain is not acting because he has not supplied it with sufficient food. He takes meat three times a day, and beef tea, to supply its wants, as he thinks, and he puts in a poker to stir it up in the shape of a glass of sherry or a nip from the brandy-bottle. And yet all the time, what his brain is suffering from is not lack of fuel, but accumulation of ash, and the more he continues to cram himself with food, and to supply himself with stimulants, although they may help him for the moment, the worse does he ultimately become, just as the child's breaking the coal may cause a temporary blaze, but allows the fire all the more quickly to become smothered in ashes. It would seem that vital processes are much more readily arrested by the accumulation of waste products within the organs of the body than by the want of nutriment to the organs themselves. In all cases of fasting, whether voluntary or compulsory, life is prolonged to a much greater extent if water be freely supplied. Without water the individual quickly dies, however much other nourishment he may get, but with abundance of water he may live for a considerable time, even if he take no solid nutriment at all. Here it is not that the water acts as a food; it supplies no new energy to the body, for unlike starch, or sugar, or fat, or proteids it has already undergone complete combustion. It cannot like them unite any further with oxygen and thus supply energy.

And yet it is more essential to life than any of them, for without it the products of waste cannot be removed from the tissues, and the vital fires, so to speak, are smothered in their own ash. If we take the excised muscle of a frog and stimulate it to repeated contraction, the contractions become feebler and feebler, until at last they cease altogether. But this is not because the fuel which the muscle contains in itself has been so completely burned up that none of it is left to furnish the requisite energy to the muscle, it is because the chemical processes necessary to the contraction of the muscle, are arrested by the accumulation of the products of its own waste. If we wash these out of the muscle by sending

through its vessels a solution of common salt, which supplies to it no new material, but which removes these waste products, the contractile power of the muscle will be restored.

This restoration takes place still more quickly and thoroughly if we employ a fluid which will supply oxygen, such as a solution of permanganate of potash, instead of a simple solution of salt, which merely washes out the muscular waste. The muscle is like a fire in the grate, which goes out long before the coal is entirely consumed, on account of the ash which smothers it, and just as we can revive the smouldering embers by supplying them with oxygen by the use of bellows, so the muscle revives more quickly when its supply of oxygen is increased. The quicker the fire burns the sooner will it be choked in ash, and the more rapidly the muscle contracts the sooner will it lose its powers.

The same is the case with the heart. The slowly beating heart of a crocodile will pulsate for a day or more after it has been cut out of the body, but the rapidly pulsating heart of a mammal will very soon cease to beat; and the more rapidly it has been beating before the animal's death, the sooner will it cease to contract afterwards. If the vagi are cut in the living animal so that the cardiac pulsations become excessively rapid, the heart's movement ceases almost as soon as the animal dies; but if during life the vagi are irritated so as to make the heart contract very slowly indeed, it comes to resemble more nearly the heart of the crocodile, and continues to pulsate for a considerable time after the animal's death. The heart, too, resembles voluntary muscles, inasmuch as if we wash out of it the products of its own waste it will continue to beat for a much longer time than if we allow them to accumulate. By simply allowing a saline solution to circulate through the heart of a frog it may be kept beating for many hours longer than if it were left to itself. Both voluntary muscles and involuntary ones, such as the heart, cease to act, almost invariably, not from exhaustion of their energy-yielding substance, but from accumulation of the waste products within them; and muscles, both voluntary and involuntary, are much less sensitive to this process of choking than the delicate structures of the nerve centres. The gastrocnemius and the heart of a frog may retain their irritability for very many hours after their separation from the body, but the spinal cord of the same animal will rarely retain its irritability for a single hour after the circulation through it has been arrested. In warm-blooded animals the spinal cord is much more sensitive than in

the frog, and if the circulation in the lower part of the spinal cord be arrested in a rabbit by the pressure of one's thumb upon the aorta for three or four minutes, the hind legs of the animal will become completely paralysed. Still more sensitive than the spinal cord is the brain, and if the circulation in the latter be arrested, consciousness is almost instantaneously abolished. In the animal body, as in the steam-engine, the governing and directing parts are much more sensitive and easily acted upon than the working parts. A single touch of the hand to the steam-valve will set the engine in action or stop its movement, although the power of a thousand men applied to the fly-wheel would avail little or nothing. And in animals the nerve centres are most sensitive and respond most readily to those circumstances which affect the organism. Not only are they exceedingly sensitive to the accumulation within them of the products of their own waste, but they are easily affected by alterations in the blood which circulates through them, and which conveys to them not only the products of muscular and glandular waste formed in other parts of the body, but also substances introduced from without, or absorbed from the intestinal canal. A single whiff of nitrite of amyl is sufficient to dilate the blood-vessels; a fraction of a grain of pilocarpine will stimulate the sweat-glands to the most profuse secretion; and half a drop of pure hydrocyanic acid is enough almost instantaneously to abolish consciousness and destroy the functional activity of the entire nervous system. In the case of the nitrite of amyl, the pilocarpine, or the hydrocyanic acid, we are able to distinguish the relation of cause and effect between the administration of the drug and the resulting changes in the organism. We do this, however, because of our knowledge, obtained by observation and experiment. Sometimes we cannot do this. I have seen, for example, a person become aware of a peculiar sensation which, to the patient, was quite unaccountable, but of which I understood the reason, as I knew it to be due to the fumes from a bottle of nitrite of amyl, which the patient could not see. We may notice a similar occurrence in poisoned animals. The poison of the cobra causes paralysis of the spinal cord and nerves, and induces intense weakness, so that the limbs of the animal fail under it. I have seen an animal in this condition attempt to walk and look round at its legs with a puzzled air, as though it could not understand what was the matter with it. It could not connect the weakness in its limbs with the introduction of the poison some

time previously, although the connection between them was to me perfectly clear.

In the same way as the action of the cobra poison was a mystery to the animal, an epidemic of typhoid fever was formerly to us a mysterious occurrence for which no reason could be assigned, but we now trace it to the absorption into the bodies of the sufferers of typhoid poison introduced from without. We are now completely alive to the important results produced by the absorption from the intestinal canal of poisonous matters, such as typhoid germs, arsenic, or strychnine introduced into it from without. But perhaps we are not yet sufficiently alive to the important results produced by the absorption from the intestinal canal of substances generated in it by fermentation or imperfect digestion. We recognise the danger of breathing gas from a sewer, but probably we do not sufficiently realise that noxious gases may be produced in the intestine, and, being absorbed from it into the circulation, may produce symptoms of poisoning. And yet we know, from recorded observations, that such is the case, and that one at least of the chief components of sewer gas, viz. sulphuretted hydrogen, may be produced in the intestine. This gas, which is so readily recognised by its smell resembling rotten eggs, was found by Dumarquay[1] to be very quickly absorbed indeed from the intestine when injected into the rectum, and to be quickly excreted from the lungs, sometimes appearing to produce, during its elimination, some inflammation of the trachea and bronchi. This was especially the case when small quantities were injected, and it seems not improbable that the production of this gas in the intestine may have something to do with the bronchitis which is not unfrequently observed in connection with digestive disturbance (p. 40). In cases of indigestion this gas seems to be not unfrequently formed, because persons often complain of the taste of rotten eggs in the mouth or in the eructations. Even in such small quantities it is not improbable that it may exert a deleterious influence both upon the nervous system and upon the blood, for it is a powerful poison, in its action somewhat resembling hydrocyanic acid, though not so strong. It destroys ferments, and robs the blood corpuscles and the seeds and roots of plants of their power to decompose peroxide of hydrogen; and as this faculty seems to be closely associated with the processes of life, the sulphuretted hydrogen may be

[1] *Comptes Rendus*, ix. p. 724.

regarded as a powerful protoplasmic poison. Upon plants it has a curious action, differing very markedly from sulphurous acid. When a plant is exposed to sulphurous acid, the leaves shrivel up, wither, and fall off, but if the plant be now removed from the noxious influence of the gas, and placed under favourable conditions, it will recover, and send out fresh shoots. But if it be exposed to the action of sulphuretted hydrogen, the leaves, instead of shrivelling, simply begin to look flaccid, and droop. This seems, at first sight, to be a less deadly action than that of the sulphurous acid, but when the leaves have once begun to droop in this way the plant is dead, and does not recover when removed from the action of the gas. This gas is rarely generated in the intestine in such a quantity as to give rise to symptoms of acute poisoning, but it has sometimes this effect. A case is recorded by Senator[1] in which a strong and previously healthy man became affected with a slight gastro-intestinal catarrh in consequence of some error in his diet, and on the second day afterwards he had frequent eructations, smelling strongly of sulphuretted hydrogen. At the same time he suddenly became collapsed, pale, giddy, and with a rapid, small, compressible pulse. This lasted for $1\frac{1}{2}$ to 2 minutes, and then passed off. The urine which he passed shortly afterwards contained sulphuretted hydrogen. On the same day he had a second attack of a similar sort, and then, the bowels having been opened, he recovered completely. Nor is sulphuretted hydrogen the only gas which may be formed in the stomach. Marsh gas is sometimes formed there too, and in an exceedingly interesting case recorded by Dr. Ewald,[2] the quantity was so great that it first attracted the patient's attention by taking fire as it issued from his mouth while he was lighting a cigar. In this curious case the formation of gas alternated with the production of a great quantity of acid fluid in the stomach, which led to vomiting, or, as the patient himself expressed it, sometimes his gas factory and sometimes his vinegar factory was at work. It is possible that this gas may be formed in small quantities in many more cases than has hitherto been suspected, but its absorption does not seem to have anything like the same deleterious action as that of sulphuretted hydrogen. Nor was the acetic acid which was found by chemical analysis to exist in the acid secretion of the stomach in this case likely to be productive of any injurious effects after its

[1] *Berliner Klin. Wochenschrift*, 1868, No. 24.
[2] *Reichert's und Du Bois Reymond's Archiv*, 1874, p. 217.

absorption. But butyric acid, which is sometimes formed in the stomach in other cases of indigestion, has been shown, by O. Weber, to be a powerful poison acting chiefly on the nerve centres.

It seems probable, however, that the substances, both gaseous and solid, formed in the stomach and absorbed from it, are upon the whole less poisonous in cases of indigestion than those which are produced lower down in the intestinal canal. We often find that patients are affected with severe gastric disorder without any affection of the nerve centres beyond the weakness produced by the inability to digest food, while in many persons the mere omission to evacuate the contents of the bowels at the usual time will lead to a headache in the course of the day. No doubt such a headache as this may be due, to some extent, to the nervous irritation caused by the presence of the fæces in the intestine, but it seems quite possible that it is also due to the absorption of some of the fæcal matter itself. Nor do we at present know what effects are produced by the absorption of the various digestive juices themselves. That such absorption takes place there can be little doubt. It has been demonstrated in the case of the bile, which is absorbed with great rapidity from the intestine and re-excreted by the liver, so that it does not pass into the general circulation at all. But what becomes of the other digestive fluids, and the ferments they contain? The pepsine finds its way in minute quantities through the liver, and has been discovered in various tissues of the body and in the urine. This, however, matters but little, for it cannot act upon the tissues themselves, inasmuch as they possess an alkaline reaction. But the case must be somewhat different with pancreatine, and if pancreatic fluid be absorbed from the intestine and pass through the liver unchanged, we should expect that it would have a very powerful action upon the tissues throughout the body, because there appears to be no reason why it should not act upon them just as it does upon the food in the intestine itself. It seems not at all unlikely, then, that the liver has got another function besides those usually assigned to it, viz. that of preventing the digestive ferments from reaching the general circulation so as to act upon the tissues. Now we do find in the liver itself and in the bile a ferment having the same diastatic power as the pancreatic juice, but it does not appear in such quantities as one would expect if the whole of the pancreatic ferment were simply re-excreted by the liver along with the bile, and as we have no evidence that the ferment is destroyed during its action in the intestine, we are

naturally led to think that it may undergo a change in the liver, the converse of that which it undergoes in the pancreatic gland during the process of secretion. In the pancreas itself we have no ready-formed ferment, but we have a ferment-forming substance, which has recently become known under the name of zymogen, given to it by Heidenhain, but the writer heard it described by Kühne in his lectures on physiological chemistry delivered at Amsterdam in 1869. I quote verbatim from the notes which I took at the time of his lecture on the pancreas. "Glands which have no action on fibrine can be made active by digesting in very dilute acid and then neutralising or alkalising; there seeming to exist a ferment-forming substance in the pancreas." During digestion this ferment-forming substance or zymogen splits up and yields free ferment, and it seems not improbable that it is in the liver that this very ferment, after its digestive work is done, becomes again converted into the ferment-forming substance which may circulate throughout the tissues without doing them any injury.

Whether this be the case or not, however, with regard to the ferments of the gastric, pancreatic, and intestinal juices, all of which must pass through the liver before they reach the general circulation, there can be no doubt that the products of intestinal digestion do undergo very marked changes indeed in the liver, as is shown by the formation from them of very large quantities of a new substance, glycogen—a substance which is not contained in the products of the gastric and intestinal digestion which reach the liver, and yet which is of the highest importance for the nutriment of the body. Under ordinary circumstances, nearly the whole of the sugar formed in the intestine and absorbed from it, is arrested in the liver, so that very little passes into the general circulation and appears in the urine, although even in healthy persons traces of sugar are excreted by the kidneys. Under exceptional circumstances, however, sugar may pass through in considerable quantities, as, for example, when the individual takes, on an empty stomach, a large quantity of syrup. However healthy his organs may be, sugar will then appear in the urine. The same is the case in regard to albumen. Usually, the whole albuminous constituents of our food are so transformed in the stomach, intestines, and liver, that no albuminous substances of the kind which can pass through the kidneys get into the general circulation. But if one takes such a quantity of eggs as to completely overtask the digestive

powers, the egg albumin will pass unchanged into the blood, and be excreted by the kidneys.[1]

Other albuminous substances, the products of intestinal digestion, and peptones also, occasionally make their appearance in the urine, as well as egg albumin. Even when the processes of assimilation are not so seriously interfered with as in these instances, we observe that products of nitrogenous waste frequently occur in the form of lithates in the urine. An excess of these indicates some pathological condition, even although it may be very trivial. We cannot, indeed, say what the exact condition is, because we find lithates appearing in the urine after violent muscular exertion accompanied by profuse sweating, so that they may possibly represent some of the products of muscular waste; but we also find that they occur in large quantities in the urine after slight indiscretions in diet, although no muscular exertion has been undergone, and in these cases we can hardly do otherwise than regard them as products of the imperfect assimilation of nitrogenous matters which ought to have been eliminated, not in the form of urates, but of urea. Now physiological experiments and observations indicate that the liver is the chief, if not the only, part of the body in which urea is formed. This at least appears to be the case excepting in febrile conditions, in which, possibly, the urea may also be formed, to a considerable extent, in the muscles. The old notion, then, which connected the appearance of lithates in the urine with disordered function of the liver, is probably in a great measure correct. There is little or no reason to believe that these lithates are formed in the kidneys. They are, probably, simply separated by them from the blood, and their presence in the urine would therefore indicate their presence in the blood and tissues. Now lithates in themselves do not appear to have any particularly injurious effects, either upon the nervous tissues or the muscles, but as their presence indicates deficient assimilation, they may be accompanied by other substances which have a much more pernicious action, just as there are many bad smells which, *per se*, though very disagreeable, have no marked poisonous action, while other very poisonous substances have comparatively little odour. Yet the disagreeable odours which accompany sewer gas, although perhaps not always dependent upon its poisonous constituents, warn us of the presence of gases which may be intensely poisonous. Nevertheless, just as the poisonous gases may be present without any disagreeable smell, so we may

[1] Brunton and Power, *Bartholomew's Hospital Reports*, 1877, p. 283.

have substances circulating in the blood which have the most injurious effect upon the nerve centres, without the presence of urates in the urine.

The importance of the functions of the liver in reference to assimilation is now generally recognised, although for a long time this, the largest gland in the body, was considered to have no other office than simply to secrete bile. Although the bile is useful in digestion it is not of primary importance in this process; but its proper secretion is probably associated very closely with the assimilative functions of the liver, and if the biliary secretion does not take place properly we can hardly expect the assimilation to be perfect.

The greatest care appears to have been taken in the construction of the liver to prevent the bile from coming in contact with the blood, the ultimate radicals of the bile ducts, or biliary capillaries, being placed as far from the blood capillaries as the structure of the liver will allow. Notwithstanding this care, the distance between the blood and the bile capillaries is small, though it is sufficient, under ordinary circumstances, to prevent the absorption of bile into the blood. But whenever an obstruction takes place to the exit of bile, and the pressure of bile in the biliary capillaries increases, an absorption of this secretion occurs. Bile is secreted under very low pressure, and a very slight increase in this is sufficient to cause re-absorption. Such an increase as would not materially affect the secretion of other glands, such as the salivary gland, is sufficient to prevent the exit of bile through the biliary ducts, and cause its re-absorption into the blood. The excretion of bile is greatly aided by the pressure which is exerted upon it by the movements of the diaphragm during respiration, and, indeed, so low is the pressure under which the bile is secreted that, but for the assistance given by the respiratory movement, it would just barely find its way into the duodenum. Although we are accustomed to say "As bitter as gall," according to my own observations fresh human bile is not bitter. When it is thrown up in consequence of indigestion it is intensely bitter. On one occasion, when making experiments with digitalis, I had taken in the course of two days one grain of pure digitalin, and brought on symptoms of poisoning, with intense vomiting. During this I brought up a quantity of bile of a golden-yellow colour, and without the least trace of bitterness. This circumstance struck me as being so peculiar that in my published results I hesitated to call it bile,

although I did not see what else it could be.[1] But when it remains long in the gall-bladder it undergoes changes, and in some cases of vomiting that I have seen the vomited matters have been of a bright grass-green colour. When examined, also, after death, the bile in the gall-bladder is not unfrequently found of a dark colour, and the same is probably the case when it is retained in the gall-bladder for any length of time during life. How the Greeks arrived at the notion of giving the name "Melancholy," *i. e.* black bile, to depression of spirits, we do not quite know, but certain it is that depression of spirits is very often associated with indigestion, and, moreover, that the form of indigestion with which we find depression of spirits associated, is not so much gastric as intestinal, or, more probably, hepatic. According to Herbert Spencer, we require rapid evolution of nervous energy in order to have exhilaration of the spirits, and depression of nervous energy is associated with melancholy. Now the effect of bile acids circulating in the blood, as shown by physiological experiments, is to depress the reflex function of the spinal cord, to lessen the functions of the brain, producing drowsiness ending in coma, and to weaken the circulation by paralysing the cardiac ganglia.[2] Such a combination of actions is just the one required by Mr. Spencer's hypothesis to produce melancholia, and here we find ancient notions joining hands with modern science.

But bile is not the only substance which produces a depressing effect upon the circulation when absorbed into it from the portal system. I have already mentioned that certain albuminous products of intestinal digestion and peptones occasionally make their appearance in the urine. Amongst the former is an albuminous substance, not precipitated by boiling, but by nitric acid in the cold. This substance I have observed in the urine of a healthy man after he had drunk a large quantity of strong beef-tea at a draught upon an empty stomach. My attention was drawn to the urine by the froth remaining upon it for a somewhat unusual time. On examination, this substance was discovered in it. On examining the beef-tea which the person had taken a similar albuminous substance was found in it, so that there can be little doubt that in this case the albumen was simply absorbed so rapidly from the stomach or intestines that it passed without change through the portal system into the general circulation, and

[1] Brunton *On Digitalis*, p. 67.

[2] *Vide* Wickham Legge, *Bile, Jaundice, and Bilious Diseases*, pp. 207, 216, 217.

thus reached the kidneys, where it was excreted in much the same way as sugar would have been under similar circumstances. We find only too frequently that both doctors and patients think that the strength is sure to be kept up if a sufficient quantity of beef-tea can only be got down; but this observation, I think, raises the question whether beef-tea may not very frequently be actually injurious, and whether the products of muscular waste which constitute the chief portion of beef-tea or beef-essence may not under certain circumstances be actually poisonous. For although there can be no doubt that beef-tea is in many cases a most useful stimulant, one which we find it very hard indeed to do without, and which could hardly be replaced by any other, yet sometimes the administration of beef-tea, like that of alcoholic stimulants, may be overdone, and the patient weakened instead of strengthened. In many cases of nervous depression we find a feeling of weakness and prostration coming on during digestion, and becoming so very marked about the second hour after a meal has been taken, and at the very time when absorption is going on, that we can hardly do otherwise than ascribe it to actual poisoning by digestive products absorbed into the circulation. From the observation of a number of cases I came to the conclusion that the languor and faintness of which many patients complained, and which occurred about eleven and four o'clock, was due to actual poisoning by the products of digestion of breakfast and lunch; but at the time when I arrived at this conclusion I had no experimental data to show that the products of digestion were actually poisonous in themselves, and only within the last few months have I seen the conclusions to which I had arrived by clinical observation confirmed by experiments made in the laboratory. Such experiments have been made by Professor Albertoni of Genoa, and by Dr. Schmidt-Mühlheim in Professor Ludwig's laboratory at Leipsic.

Professor Albertoni has found that peptones have a most remarkable action upon the blood, completely destroying its coagulability in dogs, while they have little power in this respect over the blood of rabbits or sheep. The number of species upon which he experimented is limited, so that he cannot as yet draw the conclusion with certainty that peptones prevent the coagulation of the blood in carnivora and not in herbivora, although, so far as experiments go, this conclusion seems probable. He and Dr. Schmidt-Mühlheim independently made the discovery that

peptones prevented the coagulation of the blood in dogs, and the latter, under Ludwig's direction, has also investigated their action upon the circulation. He finds that, when injected into a vein, they greatly depress the circulation, so that the blood-pressure falls very considerably; and when the quantity injected is large, they produce a soporose condition, complete arrest of the secretion by the kidneys, convulsions, and death. From these experiments it is evident that the normal products of digestion are poisons of no inconsiderable power, and that if they reach the general circulation in large quantities they may produce very alarming, if not dangerous, symptoms.

Such experiments as this open up a new and very wide field of inquiry, which is likely to prove of very great practical importance. We have hitherto been accustomed to reckon all peptones as identical, by whatever digestive ferment they were formed, and to look upon it as a matter of slight moment whether albuminous foods introduced into the digestive canal were dissolved by the stomach or by the pancreas, although it is quite possible that the peptones differ as much from each other as different kinds of sugars. It is a matter of wonder, also, that at the present moment, although the digestive processes have been so carefully investigated, we know very little of the uses of the *succus entericus.* Notwithstanding the great extent and evident importance of the intestine, and the large quantity of fluid which it is able to secrete: all that we find regarding the action of this secretion in such a book as Foster's *Physiology* is that "the statements with reference to its action are conflicting. Probably it has no direct action on either fats or proteids, but is amylolitic in some animals, though not in all. *Succus entericus* has also been said to change cane- into grape-sugar, and by a fermentative action to convert cane-sugar into lactic acid, and this again into butyric acid, with an evolution of carbonic acid and free hydrogen." The reason why experiments on the action of intestinal juice have given such an apparently unsatisfactory result is that they have been chiefly tried on such kinds of food as we are accustomed to put into our mouths. Now the intestinal juice is not intended to act upon such substances: its place is to finish the digestion begun by the other juices; and when experiments with intestinal juice are tried upon foods which have previously been subjected to the action of the other digestive fluids, positive, and not negative, results are obtained. Thus, for

example, it was stated by Kühne, in his lectures at Amsterdam in 1868-9, that though intestinal juice would dissolve raw albumen and fibrine, it would not act at all upon them if boiled; but if the boiled albumen or fibrine were first subjected to the action of pancreatic juice for a short time, the intestinal juice would afterwards dissolve them much more quickly than it would even in a raw condition. The action of digestive ferments is just beginning to find a practical application in medicine, and sometimes, undoubtedly, they are of very great service; but unless their action is investigated more thoroughly than it has been up to the present, it is just possible that we may by-and-by find that the digestive ferments, like all other powerful agents, may do much harm as well as much good. Hitherto we have been accustomed to regard the phases of digestion, gastric digestion, pancreatic digestion, and intestinal digestion, as almost separate processes, any of which we might increase indefinitely without doing any harm to the patient. We forget the relation which each bears to the other; and yet such a relation undoubtedly exists, for we find that when pepsine is mixed with bile it is precipitated and rendered inert. Further transformation of foods by the gastric juice is thus arrested as soon as the chyme leaves the stomach. And well it is that this should be so, for if the pepsine was not rendered inert it would destroy that pancreatic ferment (trypsin) which acts on albuminous substances, and thus interfere with digestion by it. How far this prolonged peptic digestion and impaired pancreatic digestion of albuminous substances has to do with the production of poisonous digestive products in cases where the quantity of bile poured into the intestine is deficient it is at present impossible to say, but it is a condition which ought to be kept in mind in all cases where there is deficiency of bile in the intestine, and the advisability of nourishing the patient by farinaceous food is constantly to be considered in these cases.

And now comes the question, How is it that in healthy conditions of the intestine peptones do not pass into the general circulation, and are therefore unable to exert any poisonous action upon the nerve-centres? This question is one which we cannot at present answer quite satisfactorily.

Usually the peptones disappear from the portal blood before it reaches the general circulation. Indeed, Ludwig and Schmidt-Mühlheim found that even in the portal blood, before it reaches

the liver, very little if any peptone is to be found. They have not succeeded in discovering where the peptone undergoes change. Plosz and Gergyai, and also Drosdorff, have discovered peptone in the blood of the portal vein, and Plosz and Gergyai have been led, by their experiments, to regard the liver as the seat of the transformation of peptones. In consideration of the more recent experiments of Ludwig and Schmidt-Mühlheim, we cannot entirely adopt the view of these authors, though it is nevertheless possible that they are to a certain extent right, and that the liver, to some extent at least, serves the purpose of preventing any peptones from getting into the general circulation, which may have escaped transformation in the portal blood before reaching it.[1]

And now, having run over in this cursory manner some points connected with digestion and with the functions of the liver, we come back to the question of why it is that the mental worker becomes depressed, irritable, melancholy, and, it may be, stupid and forgetful, after a few months' work, although every part of his body may be organically healthy, and a month's holiday may be sufficient to restore every organ to perfect functional activity? One reason, no doubt, may be that his systematic overwork may produce a diminution in the energy-yielding substance of his nerve-centres, just as we see that a certain amount of atrophy occasionally occurs in overworked muscles. But this does not seem very probable. It seems much more likely that they cease to act in the normal way because during each day's activity a certain amount of waste product is formed which is not perfectly removed during the hours of rest.

All throughout the body we have most elaborate arrangements for removing waste products. In the muscles, for example, we find that the fascia which surrounds them forms a regular pumping arrangement, the two layers of which it consists being separated from each other at each muscular relaxation, and pressed together at each contraction.[2] The lymph and the waste products which it contains are thereby actually pumped out of the muscle at each contraction, and sent onwards into the larger lymph-channels, so that the muscular action itself removes the waste products (p. 332). At the same time we find

[1] Schmidt-Mühlheim, *Archiv für Anatomie und Physiologie; Physiologische Abth*, 1 & 2 *Heft*, 1880, p. 33. Albertoni, *Centralblatt f. d. medicinischen Wissenschaften*, 1880, p. 577.

[2] Ludwig and Genersich, p. 53, *Ludwig's Arbeiten*, 1870.

that the movement of the muscles of the leg, for example, will also pump out the blood from the veins, sending it upwards from the feet, and pressing it upwards to the body.[1]

Again, we find that in the abdomen and thorax we have pumping arrangements, whereby any excess of the serous fluid which bathes the intestines and lungs is pumped out of the peritoneal pleural cavities by the action of respiration. The two layers of the central tendon of the diaphragm and of the pleura here form pumping arrangements similar to the fascia in the leg.

The brain and spinal cord, being inclosed in rigid cases, have no pumping arrangements in immediate connection with them, but the circulation of the cerebral spinal fluid in them is probably effected also by the movements of the thorax and abdomen. The cavity of the arachnoid and of the cerebral ventricles is not only continuous with similar cavities in the spinal cord, but also with the lymph-space surrounding the choroid with the interior chamber of the eye, and even with the lumbar lymphatics; and Professor Schwalbe has succeeded in injecting these parts by a single insertion of the nozzle of his injecting syringe into the arachnoid. His observations have been confirmed and extended by Althann.[2] The experiments of Quincke have shown that during life a current exists in the cerebral spinal fluid both from above downwards, and from below upwards.[3] The cause of this current is, in all probability, the respiratory movements. We have, indeed, in the brain and spinal cord, a condition not unlike that which exists in the fasciæ covering muscles, where the muscular substance during its contraction presses the flexible inner against the unyielding outer layer of the fascia, and thus produces, in the space between them, a pumping action. The skull and vertebral canal would correspond to the hard layer of fascia; and the brain and cord, which, as we know, expand and retract during the movements of respiration, when a part of their bony case is removed, will have a similar pumping action upon the cerebral spinal fluid to that of the muscle upon the lymph in the fascia.

In the case of the brain and the cord there will be, in addition, a pumping action produced by the very circulation of the blood in

[1] Braune, *Ber. der Sächs. Gesell. d. Wiss.*, 1870, p. 261.

[2] Althann, *vide Virchow's Jahresbericht*, 1872, p. 156.

[3] Several authors, as Axel Key and Retzius (*Nordisk medicinsk Arkiv.*, 1870, II, 1, 13—18; *Centralblatt für Medicinische Wissenschaften*, 1871, p. 514); Quincke (*Reichert's und Du Bois Reymond's Archiv*, 1872, 153—177; *Centralblatt für Med. Wissen.*, 1872, p. 898.)

them, the alternate expansion and dilatation, corresponding to the heart's beats, having a similar effect to that produced by the respiratory movements. As stimulation of the brain causes dilatation of its vessels, and increases the flow of blood through them, mental action of itself not only attracts more blood to the brain, but provides to some extent for the removal of waste products. The movements induced by the cardiac pulsations are not so extensive as those caused by the respiratory movements or by muscular exertion, and therefore, when the brain is overworked, and the respiration and muscular movements are underworked, the cerebral nutrition will be diminished by the imperfect removal of waste from its substance. But if, in addition to this, the cerebral cells and fibres are actually poisoned by the circulation within the vessels which supply them, of noxious substances due to imperfect digestion or assimilation, matters will become very much worse.

We have already seen how much the liver has to do with such a condition. Now, while the brain is being taxed to its utmost, the worker generally gets but very little exercise. The consequence of this is, that although the respiratory movements still go on with regularity, and the pressure of the diaphragm upon the liver at each respiration presses the bile more or less out of the liver, yet the pressure thus exerted is very much less than would be the case if the individual were making occasional vigorous efforts during which the breath was held, and the muscles of the abdomen put into action, as, for instance, in springing from boulder to boulder on the moraine of a Swiss glacier. So long as the brain-worker is exceedingly careful what he eats, so that no excess of bile is formed, and is fortunate enough to escape duodenal catarrh, so that no impediment, however slight, prevents the flow of bile into the intestine, he may get along perfectly well; but if he be unfortunate enough to get what is commonly known as cold in the stomach, or unwary enough to irritate the mucous membrane of his stomach or duodenum by wines or spirits, the case is at once altered, for now the swollen mucous membrane of the duodenum tends to close the orifice of the bile-duct, or the congestion may even extend up to the duct itself. Thus an impediment, however slight it may be, is opposed to the exit of bile from the liver. The pressure under which the bile is secreted, as I have already said, is very small, and there being no extra pressure put upon the liver by the diaphragm and abdominal muscles, instead of the bile being at once forced out of the bile-capillaries

it will remain in them, causing more or less congestion, and now follows a whole series of disagreeable results. The bile, which may be looked upon as a waste product of the liver, not being removed, the other functions of the liver are disturbed. Assimilation becomes imperfect, we find lithates appearing in the urine; the circulation in the liver itself may be altered, and thereby the whole circulation in the stomach and intestines may be impeded, for it must be remembered that all the blood from the stomach and intestines has to pass through the liver before it again reaches the general circulation. Thus the individual becomes troubled with hæmorrhoids, secretion and vermicular movement in the bowels are impaired, so that constipation results; congestion of the stomach, with loss of appetite, impaired digestion, and flatulent eructations ensue, and the brain and nervous system begin to suffer from the accumulation in them of their own waste or the absorption of abnormal products of assimilation.

Feeling weak, dull, and melancholy, the sufferer now thinks he ought to take meat three times a day, and perhaps during the intervals of his meals, to take strong beef-tea, or perhaps a glass of wine or a nip of brandy. Yet, in spite of all this, he becomes weaker, more stupid, and more melancholy; and no wonder. He is simply further over-taxing his already over-worked digestive organs. He is piling up fuel, instead of removing ash, and choking the vital processes both in his digestive and nervous systems. What he wants is not more nutriment, but a more rapid removal of waste, and the change upon the adoption of a proper system of treatment is in many cases most marked and satisfactory both to the physician and the patient.

The first thing to be done is to clear out the liver. This may seem to be an unscientific expression, one adapted rather to popular notions than in accordance with ascertained facts. But this is not the case. In a former paper on the action of purgative medicines,[1] I have explained the way in which certain purgatives may be said to have the effect of clearing out the liver, and first amongst those we must reckon mercurials. In the case which we have just been describing, five grains of blue pill may be taken at night, or two or three grains of calomel either alone or combined with extract of hyoscyamus or conium, and this should be followed next morning by a saline draught. As a saline we may use sulphate of magnesia, or Friedrichshall, Pullna, Hunyadi Janos, or Carlsbad

[1] *Practitioner*, vol. xii. pp. 342, 403.

water; but whichever saline we may choose, the use of one or other of them should on no account be omitted. One of the best salines is half a drachm of crystallised Carlsbad salts dissolved in a tumbler of hot water and drunk immediately after rising in the morning, and this may be used not merely in the morning after the mercurial, but it may also be employed every morning in cases where the bowels are constipated, The quantity of water is of considerable importance. Half a teaspoonful dissolved in a full tumbler is more efficacious than double the quantity of salt in half the quantity of water. Nor is this to be wondered at, for not only has the larger quantity of liquid greater power to wash out the intestine, but the increased amount of the water tends to increase the quantity of bile secreted, and this increase in bile is especially marked when the water is taken frequently in small quantities, as it is by persons undergoing the cure at Carlsbad, or who take the solution of Carlsbad salts at home by sipping it at intervals while dressing, instead of drinking it all off at once.

Zawilski found that when liquids were taken in this way not only was the bile secreted in greater quantity, but under a greater pressure, so much so that secretion still occurred when such an obstruction was opposed to its exit as would usually have caused the bile which had already been secreted to be reabsorbed.[1]

When the Carlsbad salts are employed after the mercurial, it is, I think, best to take them in single large draughts immediately on rising, but when used by themselves the solution should be sipped at intervals during dressing. When used alone the Carlsbad water, warmed in an ætna, or by standing the tumbler in a basin of hot water, is perhaps even better than the salts, which represent only a part of the normal constituents of the water. After the liver has been thoroughly cleared out in this manner by a mercurial purgative followed by a saline, vegetable cholagogues, such as iridin and euonymin, may be employed to assist the action of the Carlsbad salts, when these are found to be insufficient even although they are taken with regularity. These cholagogues, the introduction of which into medicine, in this country at least, we owe to Professor Rutherford, are sometimes as useful, perhaps even more so than mercury, but as a rule I think the mercurial purgative is the best to begin with. Euonymin is the cholagogue most usually employed, but iridin is really the most powerful one, and is specially recommended by Dr. Rutherford.

[1] *Sitzungsber. der Wiener Acad.*, 1877; *Mat. Nat.*, Abth. Bd. iv. p. 73.

Instead of trying to keep up the strength, as it is termed, by loading the stomach with food, the exhausted brain-worker should rather lean towards abstinence from food, and especially towards abstinence from alcoholic liquors. The feeling of muscular weakness and lassitude, which I have already had occasion to mention as frequently coming on about two hours after meals, is not uncommonly met with in persons belonging to the upper classes who are well fed and have little exercise. It is perhaps seen in its most marked form in young women or girls who have left school, and who, having no definite occupation in life, are indisposed to any exercise, either bodily or mental. I am led to look upon this condition as one of poisoning, both on account of the time of its occurrence, during the absorption of digestive products, and by reason of the peculiar symptoms—viz. a curious weight in the legs and arms, the patient describing them as feeling like lumps of lead. These symptoms so much resemble the effect which would be produced by a poison like curare, that one could hardly help attributing them to the action of a depressant or paralyser of motor nerves or centres. The recent researches of Ludwig and Schmidt-Mühlheim render it exceedingly probable that peptones are the poisonous agents in these cases, and an observation which I have made seems to confirm this conclusion, for I find that the weakness and languor are apparently less after meals consisting of farinaceous food only. My observations, however, are not sufficiently extensive to convince me absolutely that they are entirely absent after meals of this sort, so that possibly the poisoning by peptones, although one cause of the languor, is not to be looked upon as the only cause. A glass of soda-water with or without the juice of a lemon squeezed into it, may be slowly sipped when the feeling of weakness comes on, and a biscuit may be eaten along with it if desired. This will sometimes relieve languor, but if it be found insufficient, a small cup of warm but weak tea or cocoa with a biscuit will act as an efficient stimulant, although they may be less unobjectionable than the soda-water. Heat is one of the most powerful of all cardiac stimulants, and any warm fluid in the stomach will increase its action; a cup of warm water alone will do this, but it is unpleasant to take, and so something must be added to flavour it: a little claret may be used if tea disagrees, or tincture of ginger and sugar, or even some Liebig's extract. It is the local action of the warmth that we want, and in order to obtain it we may sometimes have to

put up with the inconvenience of giving substances which will be to some extent injurious after their absorption, such as beef extract or even whisky. The advice that I have given here, in recommending a glass of cold soda-water or a cup of hot tea, may remind one of the countryman in one of Æsop's Fables who fell into disgrace because he blew upon the fire to heat it, and blew upon his porridge to cool it. And yet the countryman was right, for experience had taught him that the desired result would follow his actions, even though he might not be able to explain the reason why. So we find that a draught of cold water will revive a fainting person, and hot water will have a somewhat similar effect. Both of them give relief by stimulating the circulation, but their *modus operandi* is different. In the case of the hot water the circulation is stimulated through the heart, which is excited to increased contraction, and thus the tension within the vessels is raised. In the case of the cold, the pressure is also raised, not by stimulation of the heart, but by the contraction of the vessels, especially those of the stomach and intestine. In the case of warmth, more blood is poured into the aorta by the excited heart, and where we apply cold less blood flows out of the aorta into the veins through the intestinal vessels, and thus it is that in both cases the tension is raised and the faintness removed.

At each meal it is well for the patient to begin with the solids before he proceeds to the fluids, and at breakfast, instead of beginning the meal with a cup of tea or coffee, he should finish a slice of dry toast and a piece of fish, egg, or bacon before he takes any liquid at all. The same rule should be observed at lunch and dinner. The effect of this course is that the patient is less troubled with weight and flatulence after meals. The explanation of the fact probably is that the solids, entering the stomach first, stimulate it to secretion and movement; whereas if it already contained a quantity of liquid at the time they were ingested they would not have this effect, and imperfect digestion would be the result. At dinner, wine or beer may be taken if the patient finds them agree, but in all probability he will be better without them. There are some brain-workers who require them, and must have them, but it is better for a good many others to avoid either wine or beer, and to take some effervescing water instead. Not unfrequently we hear the complaint that effervescing water is too cold, and where this is felt to be the case ginger ale or zoedone may be substituted, the colour of these beverages and

their more pungent taste rendering them more grateful both to the eye and the palate of many persons. In some cases weak claret and water may be used, and if the water be somewhat warm the mixture will be better for the patients, and will not cause the feeling of coldness in the stomach, of which they sometimes complain.

. A medicine which has long enjoyed a great reputation in disorder of the liver is nitro-muriatic acid, and I think this reputation well deserved. We do not know how it acts, but in some way or another it does tend to improve the digestion. Ten minims of the dilute nitro-hydrochloric acid either before or immediately after meals, combined with some aromatic and carminative, such as chloroform and cardamoms or orange, and from five to ten minims of tincture of nux vomica where the nervous depression is great, is a most efficient remedy.

But even with all this care in food and drink, with all this attention to what is to be taken and what avoided, with medicine morning, noon, and night, how are we to keep the liver in order without exercise? Sometimes the patient may be able to take walking exercise, but when he does it is generally only for a short time during the day, and of so gentle a character that the respiratory movements are but very slightly increased, and the liver is hardly more stimulated by the pressure of the diaphragm and abdominal walls during the walk than it would have been had the patient remained quietly at home. Time is an important element in many cases. Many a hard-worked man has his day so fully occupied that he cannot give up more than a quarter or half of an hour to exercise, and it is of importance that in this limited period he should get as much exercise as possible, and the best way to employ this brief time is by taking horse exercise. I believe it is to the late Lord Palmerston that we owe the saying, that "the outside of a horse is the best thing for the inside of a man," and it is very near the truth. A brisk trot for fifteen minutes will cause more pressure upon and stimulation of the liver than a lazy lounge of an hour or more. The time for this will depend in a great measure upon the engagements of the patient. It should not be taken immediately after a meal, and for most men whose days are fully occupied almost the only time to take it is before breakfast. A cup of milk, or a small cup of tea or coffee, with a piece of bread and butter or a biscuit, may be taken just before starting, and then the regular breakfast

will be taken with greater appetite and better digestion after the exercise is over.

By careful attention to the removal of waste products, and to the prevention of absorption of poisonous substances from the intestine, by regulation of the diet, regulation of the bowels, and exercise, in the ways just mentioned, I believe that the nervous exhaustion and depression from which brain-workers suffer may be greatly diminished, even though it may not be entirely prevented.

ATROPIA AS AN ANTIDOTE TO POISONOUS MUSHROOMS.

(*From the 'British Medical Journal,' November 14th,* 1874.)

It is, perhaps, not very generally known that one of the most perfect instances of antagonism with which we are acquainted is the power of atropia to counteract the poisonous principle of mushrooms. This principle seems to be the same, or nearly the same, in different species of mushroom, for they all seem to have similar actions. The *Agaricus muscarius, A. phalloides, A. pantherinus, Boletus Satanas,* and *Russula fœtens,* all resemble one another in action; but the effects produced by the same sort of fungus may vary in different individuals. They all act more or less on the intestinal canal and heart, and apparently also on the brain. The usual symptoms are uneasiness in the stomach, vomiting, purging, a feeling of constriction in the neck, want of breath, giddiness, fainting, prostration, and stupor. Sometimes the intestinal symptoms are most prominent; at other times, the cerebral ones. The most extraordinary action of poisonous mushrooms is upon the heart. The active principle of the *Agaricus muscarius,* or *Amanita muscaria,* was separated by my friend Professor Schmiedeberg of Strasburg, and named by him muscarin. The merest trace of this alkaloid will arrest the pulsations of the frog's heart almost instantaneously, and prevent it from ever beating again unless its effect be counteracted. But if a minute quantity of atropia be brought into contact with the organ, it will begin to pulsate again, and will go on beating for a long time. I have stopped the motions of a frog's heart by dropping a little dilute muscarin upon it, and have again made it pulsate after it had remained perfectly motionless for no less than four hours. Muscarin does not stop the heart of mammals so readily as that of the frog, but it renders the pulse slower, and intermissions are sometimes noticed in cases of poisoning by mushrooms. A little atropia at once counteracts the effect of muscarin on the heart in mammals just as it does in the frog.

But, besides this remarkable effect of muscarin on the heart discovered by Professor Schmiedeberg, it possesses one no less extraordinary upon the pulmonary vessels. This I discovered some time ago, when experimenting with a specimen of muscarin given to me by my friend. He had noticed that intense dyspnœa was one of the most marked symptoms produced by the poison. He had not, however, attempted to explain it. He had observed that during the dyspnœa the arteries contained very little blood, and when cut across hardly bled at all. On considering the matter, it appeared to me that this emptiness of the arteries and the dyspnœa might be due to a common cause, viz., contraction of the pulmonary vessels. If these vessels contract spasmodically, the blood will be prevented from passing through them, and will accumulate in the right side of the heart. The right heart and veins will consequently become gorged with blood, while none will reach the left side, so that both it and the arteries will remain empty or nearly so (see fig. 29). As the blood cannot reach the lungs to become aërated, dyspnœa occurs; for this may be produced as well by preventing the blood from reaching the air as by compressing the windpipe, and thus preventing the air from reaching the blood. This supposition of mine appeared to explain the symptoms perfectly; but it was only a supposition, and required to be tested by experiment before it could be regarded as having any value. I accordingly tested it in the following way.

Having thoroughly narcotised a rabbit with hydrate of chloral, I commenced artificial respiration, and opened the thorax, so that I could see the lungs and the heart perfectly. It is well known that with due precautions animals can be kept in this condition, for an hour or two at least, without any change occurring in either heart or lungs. The animal is so deeply narcotised that it lies as if dead, but the heart goes on pulsating as regularly as if everything were in its normal condition. Both sides of the heart are equally filled, the vena cava is only moderately distended, and the lungs are rosy. While this state of things continued, I injected a little muscarin into the jugular vein. At once everything changed. The lungs became blanched, the left side of the heart became small, the right side swelled up, and the vena cava became greatly distended. (See fig. 29.) After a short time, I injected a little atropia into the jugular vein, and instantly everything returned to its normal condition. The left side of the heart regained its former size, the right side diminished, the distension of the veins disappeared, and the blanched

lungs again assumed a rosy hue (see fig. 28). This was exactly what I expected, and consequently I was all the more distrustful of my own personal observations. A little prejudice might have led me to exaggerate the blanching of the lungs, although the condition of the heart and veins was so obvious as to preclude the possibility of error. I accordingly got two observers who knew nothing about the experiment, and repeated it before them, noting down *their* observations. These agreed exactly with my own, and I thus became sure of my facts.

As dyspnœa is observed after poisoning by mushrooms, both in animals and men, we may, I think, safely extend the results we have obtained by experiments on the lower animals to men, and say

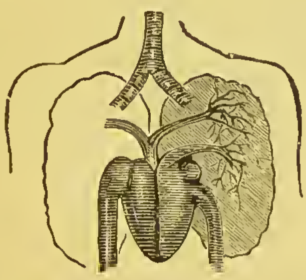

Fig. 28.—Diagram of the normal pulmonary circulation.

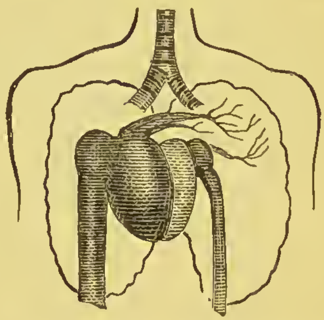

Fig. 29.—Diagram of the pulmonary circulation in poisoning by muscarin.

that in them also the dyspnœa is due to spasmodic contraction of the pulmonary vessels. The dyspnœa, as well as the other symptoms of muscarin poisoning, disappear in animals almost immediately after the injection of atropia, and, indeed, Schmiedeberg and Koppe describe an experiment in which the use of this antidote during the death-struggle completely restored a dog which had been poisoned by muscarin. They, therefore, recommend that in cases of poisoning by mushrooms, the stomach should be emptied and then atropia injected subcutaneously. It is a curious circumstance that, in poisoning by mushrooms, tickling the fauces seems to prove much more efficacious in producing vomiting than the administration of tartar emetic. The antidote may be given by the mouth, either in the form of tincture of belladonna or liquor atropiæ; but Schmiedeberg and Koppe prefer subcutaneous injection on account of the more rapid absorption and speedy action of the drug, as well as the more accurate adjustment of the dose. The dose for subcutaneous injection should be about one-hundredth of a grain or about one minim of the liquor atropiæ sulphatis (*B. P.*) repeated if necessary until the dyspnœa is relieved.

PHYSIOLOGICAL RESEARCHES ON THE NATURE OF CHOLERA.

(*Read before the British Association at Bradford, Sept.* 23*rd*, 1873.)

Printed in abstract in *Reports of the British Association* for 1873.

THE medicines which have been employed at one time or another in the treatment of cholera are almost numberless, and yet the universal dread in which this terrible disease is held, no less than the distinct acknowledgment of the uselessness of treatment which we find in medical text-books, clearly shows that the search after a true remedy has hitherto been fruitless. Empiricism having entirely failed, it only remains to be seen whether a greater means of success is to be attained by patient scientific research. I now purpose to give the outlines of an investigation which I began two years ago, but which circumstances have hitherto prevented me from completing. I should not have brought it before the Association in its present imperfect state were it not that I find a remedy, which my experiments had indicated to me as one likely to be beneficial, has lately been tried empirically in America with good results,[1] and I hope that others may be induced not merely to give this remedy a fair trial but to search for other medicines possessing properties which I am afraid this one lacks.

The cause of cholera is now generally admitted to be a poison of some sort, which can be conveyed about from place to place and transmitted from one person to another, through the medium of the evacuations which either get into water and are drunk, or become dry and are taken into the mouth and nostrils in the shape of dust. Some, even yet, are inclined to hold that cholera results rather from peculiar atmospheric and other conditions, than from the presence of a specific poison, but the fact that the disease may be conveyed from one infected locality to numerous others by a single individual, breaking out where he has stopped and passing

[1] Saunders, American *Practitioner*, July, 1873.

over those places which he has only travelled through, although these may present apparently identical conditions of air, sea, and water, shows conclusively that an outbreak of the pestilence cannot be due to these latter circumstances alone. Nor will the mere presence of the poison always produce cholera, for those who are exposed to contagion do not all become affected, and even those who have swallowed cholera stools in which the poison is supposed to be present in its most concentrated form have sometimes escaped with impunity. It would appear that two conditions are required, viz.: the presence of the poison and the existence of a proper soil for its development. In other words, it would seem that the poison does not produce its usual effects even when it has entered the system, unless the blood and tissues are in such a state that it can act upon them. The nature of this state we cannot exactly define, but its presence seems to be due in great measure to those conditions of atmosphere and soil which some assert to be the immediate cause of the disease, but which in reality only predispose to it.

Without entering into this question at any greater length, I shall assume that cholera is caused by a specific poison acting upon an organism which has become in some way or other susceptible to its influence. The effects of the poison upon the body may be summed up in a few words. It produces irritability of the digestive canal, immoderate secretion from the intestines, and lessened circulation both through the lungs and the body. Bearing in mind these actions it is perfectly easy for any one to deduce from them all the symptoms which are observed in the state of cholera collapse.

From the irritability of the stomach and intestines there is constant vomiting and purging. The secretion from them is so profuse that the whole intestinal canal is speedily washed clean out; the stools are no longer feculent nor even tinged with bile, but consist of the secretion alone, pure and unmixed and resembling rice-water in appearance. The blood is thus drained of its fluid parts, and the consequence of this is intense thirst, which adds greatly to the sufferings of the patient. The blood itself, instead of coursing rapidly through the vessels as it does in health, stagnates in the great veins of the thorax and abdomen (see diagram), the left side of the heart, instead of receiving from the lungs a full supply of well-aërated blood, which it would propel through every part of the body, receives only a scanty driblet

which leaves it almost collapsed; the arteries which proceed to the body are so empty that when they are cut across hardly a drop of blood flows from them, and even when a tube is passed through the carotid artery and aorta right up to the sigmoid valves of the heart, as was done by Dieffenbach,[1] no blood can be drawn from it. The warm blood from the interior of the body which usually circulates in the vessels near the surface, imparting to it the plumpness, warmth, and rosy hue of health, stagnates in the abdominal veins and leaves the skin shrunken, pale, and cold, while that in the interior of the body being no longer cooled by circulation near the surface, becomes hotter and hotter till the internal temperature of the unfortunate patient is higher than it usually is in high fever, though his skin and breath are cold as ice.[2] The blood which fills the small cutaneous veins being no longer driven forward by fresh supplies from the arteries, becomes completely deoxidized and black, imparting to the surface a livid hue. So dark does the blood become that it assumes the colour of bilberry juice,[3] and the colouring matter leaves the corpuscles and tinges the serum.[4] It still retains its power to take up oxygen and give off carbonic acid,[5] but notwithstanding this is passes so slowly through the pulmonary vessels that only about one-third of the usual quantity of carbonic acid is given off from the lungs,[6] and little oxygen being taken in there is a distressing feeling of want of breath. The voice at the same time is hoarse, low, and weak, but this seems to be simply a consequence of the general exhaustion of the patient.

Such are the symptoms of cholera, all rising from disturbance of the circulation and excessive intestinal secretion. The remedy we seek must, therefore, be one which has the power of removing these conditions It may be thought that the only way to do this is to eliminate from the body the poison which is producing these results, and that so long as it is still circulating in the blood any remedy which is simply intended to counteract its effects will be administered in vain. But the researches of Fraser[7] and others on

1 Dieffenbach quoted by Magendie, *Gaz. Médicale*, 1832, p. 253.

2 Güterbock, Virch. *Arch.* xxxviii. p. 30.

3 Niemeyer, *Symptomatische Behandlung der Cholera*, p. 13.

4 Parkes, on *Cholera*, p. 124.

5 This is shown by its becoming red on exposure to air, Parkes *Op. cit.*, p. 113.

6 Rayer, *Gaz. Méd.*, 1832, p. 278, and others quoted by him.

7 Fraser, *Transactions of the Royal Society of Edinburgh*, vol. xxvi.

antagonism have shown us that the elimination of a poison is not required in order to prevent its injurious or fatal action, for the administration of an antidote will deprive it of its hurtful power, and as it is with other poisons so may it be with that of cholera.

While thinking over this subject two years ago it occurred to me that if any poison should possess actions similar to those of the cholera-poison, an antidote to it might possibly prove to be a remedy for cholera. It was by no means certain that it would do so, but still in this direction seemed to be the one in which the search after a cure for cholera might be prosecuted with the greatest chance of success. I therefore began to look for a drug which would produce the same changes in the circulation which I have described as occurring in cholera. These were, I believe, first ascribed by Dr. Parkes[1] to spasmodic contraction of the vessels in the lung, which prevented the blood from passing through them, and this opinion has found a warm supporter in Dr. George Johnson. It will be readily seen that almost all the symptoms can be explained on this supposition, though there are some, as I will afterwards show, which this hypothesis does not include. The obstruction to the passage of blood through the lungs causes breathlessness by keeping the blood from the air, just as readily as it could be done by a plug in the windpipe keeping the air from the blood. The left side of the heart getting little or no blood becomes empty, the arteries do not bleed when cut,[2] the surface gets shrunken and pale, while the veins get distended, and the right side of the heart is found, *after death*, to be full of blood.[3]

If, then, Dr. Parkes's and Dr. Johnson's idea regarding the arrest of circulation were correct, the first thing to be found was some drug which would remove the contraction of the vessels in the lungs.

Some time previously, my friend Professor Schmiedeberg, now of Strasburg, had discovered and islolated a new alkaloid from a poisonous mushroom, the *Amanita Muscaria* or *Agaricus Muscarius*, and had investigated its physiological action. Among other things, he noticed that when given to animals it caused great dyspnœa.[4] At the same time the arteries became empty so that when cut

[1] [This is an error. Parkes ascribed the symptoms to arrest of the circulation in the lung, but he appeared to think the arrest was due to alteration in the blood, whilst Johnson ascribed it to contraction of the vessels. T. L. B., 1885.]

[2] Dieffenbach quoted by Griesinger, Virchow's *Handb. d. Pathol. u. Therap.*, Bd. II. Abt. 2, p. 327, and by Magendie, *Gaz. Méd.*, 1832, p. 253.

[3] Parkes, on *Cholera*, London, 1847, p. 105.

[4] Schmiedeberg and Koppe, *Das Muscarin*, p. 50.

across hardly a drop of blood issued from them, the very condition which I have already mentioned as existing in cholera.[1] From a peculiar action which it exerts upon the heart of the frog, and which is removed by atropia, he administered atropia to the warm-blooded animals suffering from the symptoms just described in the hope that it would counteract the effects of muscaria in them, just as it did in the frog. His anticipations were completely realized, and the symptoms at once disappeared after the antidote had been given. My friend had not thought at all of contraction of the pulmonary vessels as a cause of dyspnœa; he attributed it rather to excitement of the nervous centre in the medulla oblongata which regulates the respiratory movements, and the effect of atropia in removing the dyspnœa greatly puzzled him, for atropia itself excites the nervous centre, and ought, according to my friend's supposition, to have increased instead of removing the breathlessness.[2] Although he had only a very little of the alkaloid himself, Professor Schmiedeberg had very kindly given me some, and as soon as the idea that the dyspnœa was due to contraction of the pulmonary capillaries suggested itself to me I proceeded to test it by experiment. I first gave a rabbit such a dose of chloral hydrate as completely to deprive it of all sensibility, then put a tube in the trachea and connected it with a pair of bellows. I was thus able to inflate the animal's lungs at regular intervals and keep up respiration artificially when the animal could no longer breathe itself. I next opened the thoracic cavity so as readily to observe the slightest change in the lungs or heart. Fearing lest my wishes should lead me in the slightest degree to make erroneous observations, I obtained two assistants and made them tell me what they saw without my informing them of what I expected. In all the observations which we made, however, we perfectly coincided, and the results of my experiments being thus attested were carefully noted down. Our preparations being complete, I injected a little muscaria into the jugular vein. Scarcely was the injection finished when the lungs which had previously been rosy became blanched, the right side of the heart swelled up, the veins passing to it became enormously distended, and the left side of the heart almost empty. After allowing this state of things to continue for a short time, I injected a little atropia into the jugular vein—at once the effects of the muscaria disappeared and everything seemed again to present its normal appearance. The lungs again became rosy,

[1] *Op. cit.*, p. 57. [2] *Op. cit.*, p. 56.

the right side of the heart and the veins contracted, and simultaneously the collapsed and shrunken left side of the heart regained its normal fulness.

This confirmation of my ideas regarding the cause of the dyspnœa induced by the administration of muscaria and the power of relaxing the pulmonary vessels which atropia was thus seen to possess, raised my hopes regarding its usefulness in cholera. But there were other points relating to the action of muscaria and of atropia which I wished to investigate and I did not publish my results. Unfortunately my supply of muscaria failed me and I have been unable to obtain any until a month or two ago, when Professor Schmiedeberg made some more and kindly sent me a fresh supply, as soon as he had finished preparing it. Owing to other engagements I have not yet been able to prosecute my investigations, but hope shortly to do so.

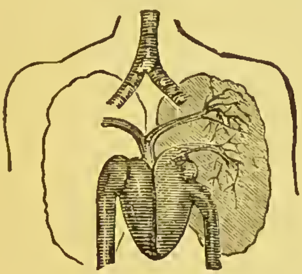

Fig. 30.—Normal.

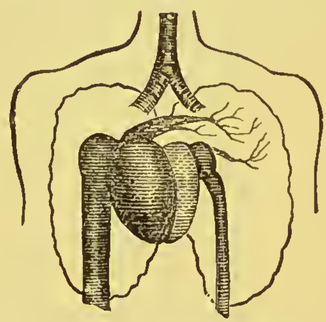

Fig. 31.—Contracted Pulmonary vessels.

I have hitherto proceeded on the assumption that Parkes's and Johnson's theory of cholera is correct, and that the stoppage of the circulation is due to contraction of the arterioles in the lungs. In poisoning by muscaria the right side of the heart seems to be almost as much distended as the great veins of the thorax and abdomen, and exactly the same condition is found in the post-mortem examination of persons who have died of cholera. But it is not certain that the right side of the heart is always distended during life even when the symptoms of cholera are present in their most pronounced form. Indeed it would appear that the veins of the intestines and the vena cava are more widely dilated in cholera than in muscaria poisoning, and hold so much blood that very little of it reaches the right side of the heart, which is therefore almost as empty as the left. There are several reasons for this supposition. The first of these is that an increase in the size of the

heart is not to be detected by percussion. On the contrary it is smaller than usual.[1] The second is that the symptoms of cholera are very similar to those of collapse or shock, produced either by mechanical violence or by the presence of a powerful irritant, such as arsenic in the intestines. In this condition the veins are widely dilated.[2] The third is that nitrite of amyl has failed to be of service in cholera. It was first tried in this disease by Drs. Hayden and Cruise of Dublin, who administered it by inhalation. It has the power of dilating the arterioles throughout the body, and, as I have shown, in those of the lung also.[3] It ought therefore to be of great service in cholera, by relaxing the spasm of the pulmonary vessels and allowing the blood to flow from the right to the left side of the heart. But it is found to be practically of little or no use. Indeed, Drs. Hayden and Cruise found that it increased the sufferings of the patient by intefering with respiration. From a knowledge of the action of the drug upon the blood I came to the conclusion that it would not hinder the breathing if it were injected subcutaneously instead of being inhaled, and I mentioned this in a paper which appeared some time ago in the *British Medical Journal*.[4] In consequence of my recommendation Dr. Smith employed it subcutaneously in a case of cholera, and found as I expected that it did not produce any difficulty of breathing. Its action on the circulation, however, was very slight. After each injection the brachial pulse was perhaps a little broader than before, but even this effect was insignificant and very transient.[5] Its action when inhaled was perhaps a little more marked, the pulse becoming somewhat stronger and the surface a little warmer than before, but the improvement was but very slight.[6] If the weakness of the pulse depends only on contraction of the pulmonary vessels, this result would be very astonishing, but if we suppose it to depend on dilatation of the great veins, this is exactly what we would expect.

A fourth argument in favour of the view that there is a great dilatation of the abdominal veins is afforded by the results of the injection of fluid into the circulation. It is evident that

[1] Griesinger, Virchow's *Handb. d. Pathol. u. Therap.*, Bd. II. Abt. 2.

[2] See Fischer, *Ueber Schok.* Volkmann's *Klin. Vorträge*, and Brunton, *Practitioner*, Oct. 1873.

[3] Brunton, *Brit. Med. Journ.*, Jan. 13. 1872, p. 44.

[4] *Op. cit.*

[5] Smith, *Indian Med. Gaz.*, May 1, 1873, p. 123.

[6] Hayden and Cruise, *Op. cit.*

all the symptoms which I formerly attributed with Parkes and Johnson to arrested circulation in the lungs, and which I have mentioned in the beginning of this paper as proceeding from diminished circulation, will be produced as readily by dilatation of the abdominal and thoracic veins and stagnation of the blood in them, as by contraction of the pulmonary capillaries. In both cases there will be a very small stream of blood circulating through the pulmonary vessels, little respiratory change in the lungs, small pulse, empty arteries, a cold skin, and high internal temperature. The only difference will be that if the circulation is arrested by an obstruction in the pulmonary vessels, the right side of the heart will be distended with blood, but if the flow is arrested by enormous dilatation of the veins the blood will stagnate in them instead of the heart, and thus the right ventricle instead of being distended will be nearly empty, and the whole organ will be smaller than usual as percussion actually shows it to be. In cholera the profuse secretion from the intestines drains away a great deal of the watery constituents of the blood, and attempts have been made to restore this by injecting saline solutions into the veins. Almost immediately after the injections the symptoms of the collapse disappeared, but returned again after a short while. Part of this improvement was in all probability due to the improvement produced by the injection in the quality of the blood, which was previously too thick, and needed dilution, but it seems highly probable that the increase in its quantity was also useful. For Schiff has lately found that when by means of an operation he produces in animals dilatation of the vessels, the introduction of more liquid into them will again restore the circulation nearly to its normal state, but in a short while the effect of this new supply of liquid is lost, and matters return to their former condition just as in cholera.[1]

From all these facts it would appear that the veins are really dilated,[2] and if so, we must employ some remedy which will make them contract.

Now there are very few experiments on the contractibility of veins, and hence we know very little about it. It has been found,

[1] Schiff, *La Nazoine*, Aug. 9, 1872, No. 222.

[2] About two months after reading this paper before the British Association at Bradford, I discovered that the theory of dilatation of the veins being the cause of the symptoms of collapse in cholera had been propounded by A. Eulenburg some years ago. *Wiener Med. Wochenschr.*, 1866, Nos. 90 and 91.

however, that in the condition of depression or shock which follows severe injuries, in which the great veins are much dilated, the injection of digitalis has been very useful,[1] and if the theory of the causation of cholera collapse which I have advanced be correct, it is likely to prove useful in cholera also.

I do not know whether atropia has a similar action on the veins or not, but it has been lately tried in cholera with great success by Dr. Saunders, of Paducah, Kentucky.[2] He writes, "In the recent outbreak of cholera in Paducah, I treated a number of cases by sulphate of atropia hypodermically—one-fiftieth to one-thirtieth of a grain in water—with the happiest results. The more distressing symptoms—vomiting, purging, cramps—were relieved almost at once, followed by refreshing sleep, continuing in some cases for several hours. I found these effects, however, to follow only when the atropia was used in sufficient quantities to produce the specific scarlatinal rash, dry throat, and dilatation of the pupils. In some cases the relief afforded was astonishing; the skin grew warm, the pulse rose, the surface, previously clammy and shrivelled, assumed its natural condition, and in some instances the patient slept soundly for ten or twelve hours, the bowels remaining undisturbed during the entire time. Of course you will not understand me as advocating the exhibition of the atropia to the exclusion of all other means, especially the use of calomel, to which I attach much importance. In the first case in which I gave the atropia I combined it with morphia (one-fortieth of a grain of sulphate of atropia to one-sixth of a grain of sulphate of morphia), and I think the combination is better perhaps than the atropia alone." I have already mentioned that my experiments with atropia in muscaria-poisoning had led me to expect great benefit from its employment in cholera, but my hopes being founded only on a supposition, viz., that it would benefit the disease because the symptoms resembled those of the poison in some though not in all particulars, I was unwilling to recommend its use until I had some positive facts to bring forward. I accordingly wrote to a friend in India desiring him to try atropia in cholera, some time before I became acquainted with Dr. Saunders's paper. I have had, as yet, no communication from my friend, and it is possible that more extended experiments may show more clearly that, as Dr. Saunders himself observes, atropia alone is not to be absolutely relied on as a remedy in

[1] Wilks, *Med. Times and Gaz.*, Jan. 16, 1864.
[2] American *Practitioner*, July, 1873.

cholera, yet the very encouraging results he has obtained by its use are such as to show that it deserves at the hands of the medical profession a careful and extensive trial.

But any search after a remedy for cholera will be very imperfect if the action of any proposed medicine on the circulation alone is considered, and its effect on the intestinal secretion left out of account. For the latter is probably even more important than the former, and it is not unfrequently present when the changes in the circulation are either slight or absent altogether. I have therefore endeavoured to discover the action of atropia on the intestinal secretion. It has been found that secretion occurs in the salivary glands under two altogether different conditions, viz., when the nerves passing to them are irritated and when all their nerves have been completely divided. In the first case the gland only secretes so long as the irritation to the nerves continues, but in the second it goes on constantly and will continue to do so for days or even weeks, because the nerves have all been cut and in this way paralyzed; the secretion is known by the name of paralytic secretion. Several years ago M. Moreau showed[1] that the same sort of paralytic secretion which has been observed in the salivary glands takes place in the intestine, and the method of experiment which he employed was this:—He kept a large dog fasting for twenty-four hours, so that the intestines should be quite empty. He then chloroformed it and drew out the small intestine through an incision in the abdominal walls. He next tied four ligatures tightly round it at some little distance from each other so as to isolate three pieces or loops of intestine. These still remained attached to the mesentery, along which the vessels and nerves run from the spine to the intestine. Leaving everything else untouched, he carefully cut all the nerves going to the middle loop, and then returned the whole of the intestine into the abdomen, sewed up the wound, and left the animal to itself for several hours. On killing it and examining the intestine, he found that the middle loop was quite full, in fact distended like a sausage by a liquid like rice-water, while the other loops remained perfectly empty. All the loops had been under exactly the same conditions with the exception that the nerves of the middle one had been cut, and therefore this profuse secretion must be due to the division of the nerves. Professor Kühne analyzed this secretion and also the rice-water-looking liquid which is secreted in cholera, and he found that their

[1] Moreau, *Comptes Rendus*, 1858, p. 554.

composition was identical, both being nothing more nor less than very watery intestinal juice.[1] Since the effect of cholera upon the intestine is the same as that of dividing the nerves, we are justified, I think, in believing that if anything can stop the secretion in this experiment it is likely to have a similar effect in cholera. Now atropia has the remarkable power of arresting the secretion from the salivary glands when their nerves are irritated,[2] and also from the sweat glands,[3] rendering the mouth and skin quite dry. What its effect on paralytic secretion in the salivary glands is, I do not know, but thinking that it might possibly arrest the flow of fluid into the intestine, I repeated Moreau's experiment, and at the same time injected some solution of atropia into the vein of the animal. On killing it some hours afterwards, I found, somewhat to my disappointment, that there was fluid in the middle loop. The dose of atropia, however, was not very large, and I comfort myself with the hope that a large dose might do though a small one would not. Whether it does so or not I cannot say yet, for I have not been able to get any large dogs for several months past, and experiments on small ones are in this case very unsatisfactory. For in them the nerves are so fine that it is not easy to be certain that they have been all divided, and so if one should find an arrest of secretion after the administration of atropia, it might be simply due to imperfect division of the nerves and not at all to the action of the drug.

Foiled in my attempts to test the remedy in this way, I had recourse to another plan. M. Moreau found that when three loops of intestine are isolated in the way I have already mentioned, and Epsom salts are injected into one of them without hurting the nerves, the effect is much the same as if the nerves had been cut.[4] I have already said that secretion may be induced in two ways, and it is very probable that this secretion is due to irritation and not to paralysis. However this may be, I tried the effect of atropia upon it both by injecting a mixture of sulphate of magnesia, with sulphate of atropia, into the intestine; and by injecting sulphate of magnesia alone into the bowel, and solution of atropia into the veins. In both cases I used atropia in large doses, which not only

1 Kühne, unpublished paper read before the Medical Society of Amsterdam, 1868-69.

2 Heidenhain Pflüger's *Archiv.* V. p. 40.

3 Sydney Ringer, *Practitioner*, Aug. and Oct., 1872.

4 Moreau, *Bull. de l'Acad. Imp. de Médicine*, 1870, p. 629.

dilated the pupil of the animal's eyes till the iris became almost invisible, but were, in fact, so large that we would hardly dare to employ proportionate ones in man for fear of causing immediate death.

Notwithstanding this, they had not the slightest influence upon the secretion, which was quite as copious as when no atropia whatever was used.

This result is disappointing and renders the use of atropia in cholera somewhat doubtful, for although the secretion caused by the sulphate of magnesia may be due to irritation, while in cholera it is due to paralysis of the nerves, yet if atropia cannot stop it in the former case it is much less likely to arrest it in the latter. It is, however, always difficult to foretell the effect of any drug under particular circumstances, and so I shall not at present speculate on the action of atropia upon paralytic secretion, but shall test it experimentally as soon as circumstances will permit.

The points in this paper to which I wish to direct special attention are—

1. Assuming Parkes's and Johnson's theory to be correct, and the impeded circulation in cholera to be really due either in whole or in part to obstruction in the pulmonary vessels, my experiments with atropia in muscaria-poisoning show that it is likely to prove beneficial to a certain extent in cholera, and since it has been found empirically to be useful in this disease, it ought to receive a fair trial at the hands of the medical profession.

2. The fact that the right side of the heart is not dilated during life in cholera patients, as well as the uselessness of nitrite of amyl which dilates the pulmonary vessels, show that Parkes's and Johnson's theory is imperfect, and that one of the most important pathological conditions in cholera collapse consists in dilatation of the thoracic and abdominal veins. Any remedy which is to be useful in cholera must have the power of counteracting this condition, and the administration of digitalis in cholera collapse may be useful.

3. The profuse secretion from the bowels in cholera is due to paralysis of some of the intestinal nerves, and a remedy which will arrest it is still a desideratum.

ON POISONS FORMED FROM FOOD, AND THEIR RELATION TO BILIOUSNESS AND DIARRHŒA.

('*The Practitioner*,' VOL. XXXV., *Aug.*, *Sept.*, *and Oct.*, 1885.)

"WHAT is one man's meat is another man's poison" is a wise saying, embodying the observation of many generations, probably indeed of many centuries. It is only within the last few years that we have begun to discover the true relationship between food and poison, through a number of researches which have been made in the last ten years, and especially in the last five, on the production of poisonous alkaloids from various sorts of food by putrefaction or even by simple digestion. Every now and again we meet with cases of individual idiosyncrasy, in which particular foods produce quite exceptional symptoms. Thus I know a lady in whom a single strawberry causes the face to swell up until the eyes become almost closed (p. 349). But in addition to these very exceptional cases, we meet with numbers of people—we might almost say classes of people—to whom certain kinds of food are more or less injurious. Milk and eggs are two of the most valuable foods we possess, and in cases of sickness where the patient is unable to take solid food, or in typhoid fever, where farinaceous foods, however easy of digestion, are, sometimes at least, injurious, milk and eggs are invaluable. Yet both milk and eggs appear to be more or less injurious to many healthy persons, and have the evil reputation of being bilious. If we inquire more precisely what is meant by this term we find that these foods are apt, when taken at all freely, to produce sensations of discomfort which are referred partly to the digestive and partly to the nervous system. Sometimes these sensations appear within one or two hours after taking the particular food which disagrees; at other times they may not appear until its use has been continued for several days. For example, one person, an hour after taking eggs or milk, feels an

unpleasant taste in the mouth, general malaise, and a frontal headache. In others, after eggs have been taken for two or three days together, the appetite becomes impaired, the intellect appears less clear, the conjunctivæ slightly yellowish, headache may occur, and the discomfort may culminate in an attack of vomiting or diarrhœa, or both. The vomiting and diarrhœa are sometimes, though not always, preceded by constipation; and both eggs and milk, on account of their constipating quality, are popularly known as "binding."

In some sensitive persons eggs do not merely produce the symptoms of so-called biliousness, but act as violent poisons. A well-marked instance of this kind I have seen in a friend of my own, who was attacked with violent vomiting and purging whenever she happened to take even a very small quantity of egg. So sensitive was she, that on one occasion she was persuaded to eat a small portion of cake by the assurance that it contained no egg. Unfortunately the statement was incorrect, and even the small piece of cake produced the usual symptoms of poisoning by eggs in her. In such a case as this the effect of the food as a poison appears to depend on the individual who takes it. With certain articles of food, which occasionally produce poisonous effects, these effects may be due in some instances to the individual who takes them, but in others to changes in the articles of food themselves. Thus cucumbers and melons are apt to bring on diarrhœa, which may be due in some cases to a peculiar sensitiveness of the persons who eat them, but in other cases the disagreeable consequences may ensue from an accidental development of purgative principles in the fruits themselves. There appears to be a tendency to the formation of purgative substances in all plants belonging to the natural order Cucurbitaceæ, of which the cucumber and melon are members. In the colocynth and elaterium plants the purgative properties acquire a high development, and even the cultivated melons and cucumbers appear sometimes to show a tendency to reversion in the same direction, and to acquire purgative properties more or less strong. In the case of animal food we find that poisonous properties are apt to appear either from particular modes of cooking, or from commencing decomposition. Thus, meat which has been baked in a pie, without a hole in the crust by which to ventilate it, is more apt to disagree than the same meat boiled or roasted. Meat which has been kept until it has become high, or fish which has become tainted, is also very apt to produce symptoms of poisoning.

Till within the last few years we have been very much in the dark regarding the causes of the different phenomena just mentioned, viz. : the tendency of milk and eggs to produce biliousness, or to be actually poisonous to certain persons, and of nitrogenous food such as meat, fish, or cheese to act as poisons when putrefaction has commenced, or of farinaceous food such as rye and maize to become poisonous when attacked by fungi. Even yet a great deal remains to be done before the subject is thoroughly cleared up, but so much has been done by recent researches that it may be useful to give their results shortly and to indicate the bearing of these results on the pathology of disease, and more especially on the pathology of biliousness and diarrhœa. The cardinal fact which results from all these researches is that albuminous, or perhaps to speak more correctly proteid, substances which are themselves foods may be split up so as to yield poisons. This decomposition is usually originated by various species of low organisms, and especially of bacilli, but it may be effected by the digestive ferments of the healthy body. The poisons formed by the decomposition of proteid bodies such as albumen, fibrine, and gelatine vary not only according to the particular body which is decomposed but to the particular organism or ferment which sets up decomposition, and according to the temperature at which it occurs and the length of time that it continues. Some of the products of the decomposition of proteid bodies are poisonous, others are innocuous. Amongst the poisonous bodies we find various degrees of activity, some being but slightly poisonous, while others are most virulent. When these poisonous products are separated from each other and isolated, they may remain unaltered and retain their properties for a length of time, but, when mixed together, they are apt to undergo further decomposition and become inert.

In order to make it easier to remember and understand these different changes, I may perhaps be allowed to use a very homely comparison between the food we eat and the utensils we employ at our meals. Albuminous food will ordinarily do us no harm, although a large quantity of it eaten at once may mechanically produce uncomfortable distension of the stomach. The glass tumbler or earthenware plate that we use in taking our food or drink are also safe to handle, and will do no harm unless they strike with exceptional violence against some part of the body. But this holds good for albumen and for our utensils only while they remain whole, though the nature of the wholeness is different

in the two cases, being chemical in that of albumen and mechanical in that of the utensils. When the tumbler or plate is broken across, the sharp edges may render them liable to cut the fingers, but the pieces may be put together with cement and they again become useful as before. When the chemical molecules of which albumen is composed are broken up in the process of digestion into peptones, these molecular fragments become dangerous, and peptones, when injected directly into the jugular vein, act as powerful poisons, producing loss of coagulability of the blood, fall of blood pressure, and death. But in the healthy body the peptones, formed by the digestion of albuminous matters in the digestion, do not enter the general circulation. Like the broken plate they appear to be cemented again into the kind of albumen known as globuline, during their passage through the portal vein and the liver. But it is not when the tumbler is merely broken in half, or albumen simply decomposed into peptones, that the fractured products are most dangerous. It is when the tumbler is broken into splinters that the pieces are most likely to produce serious injury; it is when albumen has been split up so as to yield organic alkaloids that the products of its decomposition are most poisonous. Amongst the broken glass we may find several pieces which have no sharp points and little, if any, sharp edge, so that they will be almost innocuous, while others may have a point and edge as sharp as a dagger, and capable not only of producing injury but of destroying life, and amongst these sharp pieces we may find some which are much more dangerous than others. In like manner amongst the products of decomposition of albumen we find some which are innocuous and others which are poisonous, and amongst the poisonous we find various degrees of virulency. If we select from amongst the splinters of glass one with a sharp point and edge and lay it aside by itself, it may retain its dangerous qualities unimpaired for years; but if we leave it to be shaken about amongst the rest, and still more if we continue the very process of striking by which the splinter was at first formed, its point will be broken, its edges blunted, and it will become once more harmless. Similarly the poisonous products of albuminous decomposition when isolated may retain their properties unimpaired, but, if allowed to remain together, and still more if exposed to the continuous action of the putrefactive process by which they were at first formed, they undergo further change and again become innocuous. On this account the products of the decom-

position of albuminous matters vary much in their poisonous properties according to the time during which decomposition has gone on. At first they are only slightly poisonous, later on they become intensely poisonous, but at a later stage still their poisonous qualities disappear, and they become more or less innocuous.

It is evident that the splinters of glass will vary according to the kind of glass, mode of striking it, and the force which we employ. If we break a large soda-water tumbler we will get longer, stronger, and more dangerous fragments than if we break a wine-glass, but the force which would splinter the wine-glass might simply crack the tumbler, and that which would split the tumbler into dangerous splinters might crush the wine-glass into harmless fragments. In the same way we find that the nature of the albuminous material influences the nature of the products of putrefaction. When putrefactive bacteria are sown on the flesh of mammals, the substance they produce is an exceedingly active poison, neurine, while they produce when sown upon fish another poison differing chemically from neurine although closely allied to it and resembling it also in physiological action. This poison, muscarine, is very interesting, inasmuch as it had only been obtained from a plant, the *Agaricus muscarius*, or fly-fungus, until it was discovered by Brieger to be a product of the decomposition of fish. Brieger has also found that the typhoid bacillus, when cultivated in peptone, forms no poison, but when cultivated in meat jelly or meat infusion it forms two poisons which he has not yet isolated completely. One of these causes salivation, diarrhœa, and paralysis; the other causes violent and exhausting diarrhœa. The importance of an exact knowledge of the substances which are produced by the decomposition of various foods by the actiou of typhoid bacilli on them is obvious. The plan of treating typhoid fever by an exclusively milk diet has probably saved many lives, but our use of this plan is to a great extent empirical. We do not fully know why it is successful, and although we may suppose that it is because the milk is non-irritating and does not irritate the intestinal ulcers, that is probably only a part of the truth. For milk may, and sometimes does, form very hard clots, which may pass through a great part of the intestine undigested, and as we see in children may actually be voided in this condition. Farinaceous food on the other hand is chiefly digested by the saliva and pancreatic juice before it reaches the lower part of the small intestine, and even if it did pass over the ulcerated surface

ought to do no harm by its mechanical action. Acting on this idea I have sometimes given starchy food in typhoid fever, but in a few trials it seemed to cause a rise in temperature, and I therefore abandoned it. If the effect of food in typhoid fever is a purely mechanical one upon the ulcerated intestine, calf's-foot jelly ought to be tolerated; but if the typhoid bacilli decompose gelatine so as to produce alkaloids having a violent purgative action, the jelly will be very injurious.

The temperature at which the putrefactive processes occur greatly influences the rapidity with which the albuminous substances split up, and the nature of the products which they yield. When the temperature is low decomposition occurs slowly, but does so quickly when it is high. It is probable that it may be much modified by other factors, such as the quantity of moisture in the albuminous substance itself, or in the atmosphere generally; and also by electrical atmospheric conditions, such as those which occur before or during a thunder-storm, for it is an old observation that meat as well as milk often becomes tainted during the electrical conditions which are popularly expressed by the term "thunder in the air." The difference between the products of decomposition in hot and cold weather is illustrated by the alkaloids obtained from decomposing maize in summer and winter. The alkaloid which it yields in winter has a narcotic and paralysing action; but when it decomposes during summer it yields, in addition to this alkaloid, another one which has a tetanising action somewhat like strychnine. As the putrefactive processes go on more quickly during summer albuminous substances become poisonous much sooner than in winter, and again lose their poisonous properties more quickly by the progress of decomposition. As putrefaction may go on to a certain extent after the introduction of food into the intestinal canal, and will probably from the higher temperature and greater moisture go on even more quickly than outside, it is evident that poisons may be formed from the part eaten, and produce dangerous symptoms, while no poison can be found in the remaining parts of the same food. This is perhaps of special importance in regard to milk when used as a food for infants. Milk may apparently be quite sweet at the time it is given, and yet it may be really "on the turn," as the term is. When swallowed by the infant it may rapidly become sour, and disagree, while a portion of the same milk, especially if kept cool, may appear to continue sweet for some hours afterwards. It is highly probable that not the least advan-

tage possessed by milk drawn directly from the breast, over that given by a bottle, is that the former is free from bacteria with which the latter is apt to be contaminated. Both may appear to be equally sweet when administered to the child, but the organisms present in the baby's bottle will continue their action after the milk has been taken, and render it liable to produce vomiting and purging, which, as we shall presently see, are symptoms of poisoning by putrefactive alkaloids.

The risk of contamination is much greater when a bottle with a long tube is used, for the bacteria readily find a lodgment in it; and it is to be remembered that not only do the bacteria present in the milk at the time it is swallowed continue to decompose it in the stomach, but they continue to multiply, so that if even a few are present in the milk when it is taken they may within a short time multiply greatly, and produce extensive changes in the food if they find conditions favourable to their growth in the intestinal canal.

I have already mentioned that even the primary products of albuminous decomposition by digestive ferments such as peptones are poisonous. But Brieger has lately shown that pepsine will split up albuminous substances still further, so that by digesting fibrine with artificial gastric juice he has obtained an alkaloid to which he has given the name of peptotoxine.

The bitter taste which appears during the digestion of meat, or of milk artificially, is suggestive of the formation of some alkaloid, but I do not know whether Brieger has ascertained this bitterness to depend on the presence of an alkaloid or not. Of late years the use of digestive ferments, and of artificially-digested foods, has become so common that a study of the products of albuminous decomposition is becoming of extreme practical importance, for it is possible that digestive ferments, like other powerful agents, may be edged tools, and capable of doing harm as well as good.

When we consider how many conditions influence the nature of the products of albuminous decomposition we cannot be astonished to find that very different substances have been attained by different experimenters. The chemical operations required to isolate the different products are so complicated and laborious that most experimenters have been satisfied with obtaining extractiform bodies, and have not attempted to crystallise them. But without obtaining them in a crystallised form one cannot be sure that they are pure, and the recent investigations of Brieger are therefore of great importance, because he not only obtained several products of

decomposition in a crystalline form, but has subjected them to organic analysis, and thus ascertained their chemical composition. The products of decomposition, or, as returning to the illustration we have already used, what we may term the splinters into which the albuminous molecule breaks up, are partly poisonous and partly innocuous. One fragment, as we may term it, which Brieger has got from flesh, is a substance called neuridine, which is innocuous, another, neurine, which is poisonous. From decomposing fish he has obtained a third substance, muscarine, which is more poisonous still, and two other substances, ethylenediamine, which is also poisonous, and gadinine, which is innocuous.

Besides the substances which Brieger has got from decomposing flesh, fish, and cheese, in which decomposition has been artificially induced, he has obtained from human corpses, a different set of bodies, one of which he calls cadaverine, and the other putrescine, which are feeble poisons, and two others which are produced later and are more powerful poisons, causing paralysis and death.

In addition to the alkaloids obtained by Brieger, a number of poisons have been got by other workers from decomposing articles of food or from dead bodies, and even from portions of healthy animal bodies. Although these may perhaps not have been got in the same state of purity, nor have had their chemical constitution so well defined as Brieger's, they are still of great interest and importance. It is evident that when putrid substances are introduced into the body we must be careful to distinguish between the effects produced by the poisonous products of albuminous decomposition and those of the bacteria themselves, for the bacteria after their introduction may act upon the blood and tissues, and form poisons within the body itself even though none were present in the matter injected. Kerner appears to have been the first to suspect the formation of alkaloids by the decomposition of albumen, and in 1820 he pointed out the resemblance between the symptoms of poisoning by sausages and by atropine. He made experiments upon animals, and appears to have thought at first that an alkaloid was present in the poisonous sausage, but afterwards he forsook the idea and regarded the fatty acids as the poisonous agent.

The researches of Magendie and Gaspard on the effects of decomposing organic substances were important, but rather as affording a starting-point to researches on the effects of low organisms on

the animal body than on the effect of chemical poisons produced in the putrefaction.

In 1856 Panum showed that the inflammatory change which occurs in the intestinal mucous membrane of animals poisoned by putrid matter is not due to the microbes contained in it, but to a chemical poison which remained unaltered when its aqueous solution was boiled for a long time. His conclusion that the poison contained in putrid matter was of a chemical nature was confirmed by C. O. Weber, Hemmer, Schweninger, Stich, and Thiersch.

Bergmann and Schmiedeberg isolated a crystalline poison from decomposing yeast, to which they gave the name of sepsine.

Bence Jones and Dupré found a substance resembling quinine in the liver.

Zuelzer and Sonnenschein obtained both from macerated dead bodies and from putrefied meat infusion small quantities of a crystalline substance which exhibited the reactions of an alkaloid and had a physiological action like atropine, dilating the pupil, paralysing the muscular fibres of the intestine, and increasing the rapidity of the pulse.

Rörsch and Fasbender obtained from dead bodies a substance which had properties like digitaline, but which was not crystalline.

Gautier obtained from putrefied proteid substances, and also from the secretions of living beings, alkaloidal bodies having a poisonous action. But the greatest impulse to the study of putrefactive poisons was given by Professor Selmi of Bologna, whose researches were unfortunately too soon brought to a close by his death. To alkaloids formed by the decomposition of proteid substances he gave the name of ptomaïnes, by which they are now known. It was at first supposed that these differed in their nature from organic alkaloids formed by vegetables, and various reactions were given to distinguish between them. Recent researches appear to show that this distinction can no longer be maintained, and that both animal and vegetable alkaloids are similar in their chemical constitution, and are both products of albuminous decomposition. I have already mentioned Brieger's discovery that an alkaloid peptotoxine is formed during the digestion of fibrine by artificial gastric juice. Pellicani has found a poison in the suprarenal capsule, and sometimes ptomaïnes may be obtained from the flesh of healthy animals. It is, therefore, probable that poisonous alkaloids are continually being formed in healthy men and animals by the decomposition of albumen in the intestinal canal

during the process of digestion, or in the blood and tissues generally by the metabolism which occurs during the functional activity. A considerable portion of these alkaloids is in all probability destroyed in the body, but some are excreted in the urine and fæces, from both of which powerful poisons have been extracted.

It used to be an old saying that nature never provided a poison without providing an antidote, and the fact that the dock leaf and the nettle usually grow together is often pointed to as an illustration. In the case of poisonous alkaloids there seems to be a good deal of truth in this saying, for various poisonous alkaloids which have an antagonistic action to each other appear to be produced by albuminous decomposition. It has not yet been ascertained how far the symptoms of poisoning from decomposing fish, flesh, or sausages, or from the retention of morbid products of the organism itself, such as we see in cases of uræmia, depend upon a single poison or on a mixture of poisons. It seems, however, very probable, that in many such cases we have more poisons than one, and that the comparative absence of symptoms in some cases may be due to one poison counteracting another. Brieger has found that two of the most important alkaloids produced by putrefaction are neurine and muscarine; and to these may be added a third substance, choline. Choline is obtained by boiling bile, brain, or yolk of egg, with baryta, and gets its name of choline from its having first been obtained by treating bile in the way just mentioned. It has for some time back been considered to be identical with neurine, but Brieger has been led by his recent researches to regard choline and neurine as two different bodies, though very closely allied in their chemical constitution. By oxidising choline, obtained either from bile or from yolk of egg, with strong nitric acid, Schmiedeberg and Harnack have prepared artificial muscarine, which is almost, though perhaps not quite, identical with that which is found naturally in a poisonous mushroom (the *Amanita muscaria*). Recently Boehm has subjected choline and muscarine to a careful examination, and while he finds that their action is somewhat the same in kind, it varies in degree; muscarine being very much stronger than choline, and having a marked action on the heart of the frog which choline lacks. Artificial muscarine differs also to a certain extent from natural muscarine, inasmuch as the artificial alkaloid possesses a paralysing action on the ends of motor nerves, somewhat resembling that of curara, while the natural muscarine, if it possesses this action at all,

has it only to a slight extent. With small doses the effects of artificial and natural muscarine are almost identical, and it is only when the dose is large that the paralysing action upon the motor nerves of the artificial muscarine becomes evident. It may be said that all three bodies—choline, neurine, and muscarine—have a similar action, but choline is much weaker than the other two. The lethal power of neurine is nearly ten times, and that of artificial muscarine fifty times, as great as that of choline. The most marked symptoms which they produce are salivation, diarrhœa and vomiting, dyspnœa, paralysis, and death. They seem to stimulate the secretion of glandular organs, because along with salivation there is also a flow of tears, and the secretion of bronchial mucus is rendered abundant and fluid, as is shown by the occurrence of abundant moist *râles* within the chest. The dyspnœa, however, is not entirely due to abundant secretion of bronchial mucus in the lungs, because even in frogs choline produces a peculiar alteration of the respiration and dyspnœic movements.

Muscarine and neurine produce in frogs a complete arrest of the cardiac pulsations, the heart stopping in diastole;[1] but this cannot be regarded as the cause of the dyspnœa, because the respiratory movements in frogs are not dependent on the circulation in the same way as they are in warm-blooded animals. In mammals[2] muscarine and neurine render the beats of the heart slow and weak, but do not usually arrest the cardiac pulsations, so that the heart is commonly found to be beating after death has occurred. The dyspnœa produced by muscarine has been attributed by Schmiedeberg to excitement of the respiratory centre in the medulla oblongata;[3] but I am inclined to think that in all probability contraction of the pulmonary vessels may have something to do with it; for one of the most marked points about the action of muscarine, neurine, and choline, is the extraordinary effect of atropine as an antidote to them. In animals poisoned by any of these three substances the subcutaneous injection of atropine stops the salivation, arrests the diarrhœa, and removes the dyspnœa. It also prevents death from these poisons, but only within certain limits: for if the dose be very great, the animals may still die. More especially is this the case with choline and artificial muscarine which paralyse the ends of the motor nerves, because the curara-like action is not

[1] Brieger, *Ueber Ptomaïne*, pp. 26 and 34.
[2] Brieger, *Op. cit.*, pp. 29 and 34.
[3] Schmiedeberg and Koppe, *Das Muscarin*, p. 50.

counteracted by atropine, but is perhaps rather increased, atropine itself having also the power of paralysing the motor nerves when given in large doses. The effect of muscarine and neurine on the heart is also removed by atropine. It is possible that atropine removes the dyspnœa by destroying the effect of these drugs upon the heart and thus allowing the circulation to go on freely again, Yet as I have mentioned in a former paper, the injection of muscarine causes the lungs to become pale, while the subsequent administration of atropine makes them regain their normal rosy colour, and I am inclined to attribute the dyspnœa produced by muscarine, partly at least, to contraction of the pulmonary vessels, and to regard the dilatation of these vessels by atropine as one of the reasons at least why this drug removes the dyspnœa.

Although, as I have already said, we do not as yet know that ptomaïnes, having a physiological action like atropine, are generated in the intestines or in the tissues, at the same time as muscarine, neurine, or choline, it appears quite possible that such may be the case, and that we may have symptoms occurring which are due either to the mixture of two alkaloids or to the preponderance of one or other. A case of uræmia which I saw a few days ago was strongly suggestive of poisoning by a mixture of atropine and muscarine. The secretion of urine had completely stopped, the skin, eyes, and mouth were all dry, the pupil was somewhat dilated, the pulse was beating at the rate of about 130, the mouth was held constantly open, and the breathing was laboured and gasping, but air entered abundantly into the lungs, and there was no secretion of bronchial mucus. All these are symptoms such as we find from poisoning by atropine, but in two respects the symptoms resembled those produced by muscarine, for the skin was pale instead of being scarlet as in belladonna poisoning, and when cups were applied over the region of the kidneys in order to restore if possible the renal secretion, very little blood flowed from the incisions (cf. pp. 255, 256).

I have already mentioned that Zuelzer and Sonnenschein have obtained from putrefying meat infusion, a substance having the chemical reactions and physiological effects of atropine; and some such alkaloid appears to occur frequently in poisoning by sausages, so that in a case of sausage poisoning at Wildbad in 1793 the medical man who treated the case came to the conclusion that some one either through carelessness or design had put belladonna into the sausage.

In another case of sausage-poisoning described by Dr. Kaatzer, a family ate some smoked sausage at their mid-day meal; in half an hour afterwards they became unwell, with feelings of languor fatigue, and drowsiness, yet with such dryness of the mouth that they were unable to sleep, and were obliged to be constantly drinking. In addition to this, the father had obstinate vomiting. Next day the dryness of the throat was so much greater they could hardly swallow, and the sight became affected. On the third day. the symptoms were worse, the pupils were widely dilated, there was double vision, dryness of the mouth and of the nose, and when bread was chewed it was ejected again from the mouth as dry as when it was put in. Next day the child of twelve years old died with symptoms of œdema of the lung; and the father, though much affected, could not weep as his lachrymal secretion was paralysed. The father and mother gradually improved, but on the fourteenth day of the poisoning there was still complete paralysis of accommodation. In all of them, just as in the case of uræmia which I have just mentioned, there was paleness instead of redness of the face—a symptom which I am disposed to regard as possibly indicating the presence of a muscarine-like poison, in addition to one like atropine.

In other cases of sausage-poisoning additional symptoms have been noticed, which point to the existence of a muscarine-like poison also. These are the presence of diarrhœa, alternating with constipation, and of colic. The pulse also is sometimes slow, small, and almost imperceptible—a condition which is typically that of muscarine poisoning, while in atropine poisoning the pulse is rapid from the complete paralysis of the inhibitory fibres in the vagus which the poison produces.

It is possible that instead of there being two or more poisons having a partly antagonistic action there may be only one having an action resembling atropine in some respects and muscarine in others. In some cases of poisoning by fish the symptoms have been those of poisoning by atropine, viz., dryness of the mouth, difficulty in swallowing, weight of the limbs, paralysis of the superior and inferior recti and of the oblique muscles of the eyes, as well as ptosis and paralysis of accommodation, dilatation of the pupil and double vision. The pulse was, however, not quickened as it is in poisoning by pure atropine.[1] V. Anrep[2] states that he

[1] Schreiber, *Berlin. klin. Wochenschr.* 1884, xxi. pp. 162, 183.

[2] V. Anrep, *Vratch,* 1885, p. 213, abstracted in *London Med. Rec.*, 1885, p. 271.

has isolated an alkaloid from poisonous fish, which produces similar symptoms to those just described as caused by fish itself, and Vaughan[1] has obtained from poisonous cheese an alkaloid which he calls tyrotoxicon which produces symptoms similar to those caused by cheese or by fish. If the alkaloid should turn out to be perfectly pure we should be obliged to regard them as having an action similar to atropine in many respects, but differing from it in respect to their action on the pulse. When we remember, however, how many vegetable alkaloids previously supposed to be pure have been recently shown to be mixed with others having a perfectly opposite action, we may still regard it as probable that the symptoms of poisoning by sausages, fish, &c., may in many cases be due to a mixture of alkaloids.

In cases of poisoning by a ptomaïne having a purely atropine-like action, the treatment indicated, which has also been adopted in at least one case, is the administration of physostigma either by application to the eye, or, perhaps still better, by subcutaneous injection. In cases, however, where the symptoms are of a mixed character, our knowledge of the combined effects of the poisons is sufficient at present to enable us to decide with certainty whether medication of this sort would be useful or injurious in any given case, although we may try that alkaloïd as a remedy which will tend to remove the most prominent or distressing symptoms. It is evident that if an atropine-like poison is present in the body at the same time with choline, neurine, or muscarine, in sufficient quantity to antagonize them, the effects of those latter poisons will hardly be observed, although they may possibly evidence their presence by producing diarrhœa alternately with constipation. But if they are present alone, they may be expected to produce salivation, vomiting, purging, and collapse, according to the quantity which is taken into the system.

Where the symptoms are markedly those of a muscarine-like poison, we may try atropine as a remedy; and in one case lately it seemed to me to do good. A servant girl had taken at dinner some fried liver, and ten hours afterwards she was seized with vomiting and purging, which lasted the whole night. I saw her next morning and gave her some bismuth and soda, but the vomiting continuing I gave her fifteen drops of tincture of belladonna, and there was no vomiting afterwards. Of course this single case is quite insufficient to found a treatment upon, but I think that the

[1] Vaughan, *Detroit Lancet*, August 1885, p. 60.

administration of belladonna or atropine may be worth a trial in cases of poisoning by articles of food where the symptoms are those of muscarine or some allied poisons.

Four alkaloids which Brieger has isolated from cadavers, viz., neuridine, cadaverine, putrescine, and saprine, have no marked physiological action; but he has isolated from human cadavers in an advanced stage of decomposition two alkaloids having a very powerful physiological action. One of these, when injected into guinea-pigs or rabbits, appeared to affect the intestine alone, and to have no action on any of the other organs. It caused an enormous increase in the peristaltic action, which lasted for several days, and the continuous diarrhœa led to extreme weakness of the animals.

Another alkaloid, which he terms mydaleïn, has a still more marked physiological action, and one which is of great clinical interest, inasmuch as we find amongst the symptoms a rise of temperature. No one who has watched cases of acute disease, such as pneumonia, can have failed to see how a rise of temperature sometimes coincides with the occurrence of constipation, and is removed by opening the bowels. In the case of such an acute disease as pneumonia, one has hitherto been unable to say definitely why constipation should produce this rise of temperature, but it seems not improbable that it may be due to the absorption from the intestine of some ptomaïne. In his work on *Purgative Medicines* also, Hamilton says that in cases of typhus fever the administration of an antimonial remedy "was beneficial only when it moved the belly. In this case the fæces were black and fœtid, and generally copious. On the discharge of these, the low delirium, tremor, floccitatio and subsultus tendinum which had prevailed were abated; the tongue, which had been dry and furred, became moist and cleaner; and a feeble creeping pulse, acquired a firmer beat."

The action of mydaleïn is according to Brieger perfectly specific in its nature. When a very minute quantity of it is injected into guinea-pigs or rabbits the under-lip in a short time becomes moist, the nasal secretion becomes more abundant, and a copious secretion of tears occurs. The pupils then become dilated, the vessels of the ear become much injected, and the rectal temperature rises from 1°—2° C. The pupils gradually dilate to the maximum and cease to react to light. The coat of the animals becomes staring and sometimes they tremble; gradually the secretion of saliva diminishes, the respiration and pulse, which at first were very rapid,

become slower, the temperature falls, the ears become paler and the animals recover. During the action of the poison the animals show a tendency to sleep, and the peristaltic action of the intestine is increased. When larger doses are injected into guinea-pigs, even although they are still under half a centigramme ($\frac{3}{40}$ of a grain), their action is exceedingly violent and always fatal. The secretion of all organs composed of involuntary muscular fibre becomes exceedingly profuse; and the saliva becoming mixed with the intestinal discharges, the animals constantly lie in a puddle, especially as the power of motion is impaired; exophthalmos occurs and the dilated pupils are difficult to examine on account of the profuse lachrymal secretion. When the action of the poison has attained its maximum the animals fall down, first the hind legs and then the fore legs becoming paralysed; fibrillary twitchings are visible in various groups of muscles, and the respiration becomes more and more violent and gasping. Sometimes the animal makes a sudden upward spring, raising its head and gasping for air; then it sinks down again and lies in its excrement, making slight defensive movements with its legs. The temperature gradually sinks, the movements become slighter and slighter, and finally the animal dies. On post-mortem examination the heart is found standing still in diastole and the bladder and intestine are contracted, but there is nothing else abnormal. In cats mydaleïn caused dilatation of the pupil; profuse secretion of tears, saliva, and sweat, vomiting and diarrhœa: to these succeeded paralysis first affecting the hind-legs and then the fore-legs, occasionally convulsive twitchings, laboured breathing, coma, and death. On post-mortem examination the heart was found standing still in diastole, the intestines contained a little thin fluid secretion, and the mucous membrane was injected. This alkaloid is, as I have already said, very interesting from the rise of temperature which it produces; but we do not as a rule find all the symptoms here described as characteristic of poisoning in animals occurring usually in men, either in cases of disease or in consequence of poisoning by decomposing food, although a number of them may occur. It is possible that the occurrence of some and not of others may be due to the occurrence in disease of alkaloids allied to mydaleïn, although not identical with it; or to the presence of two or more alkaloids which partially neutralise each other's effects.

It is quite evident that it would be unjustifiable to conclude that because alkaloids are formed by the decomposition set up by

bacteria in albuminous matters outside the body, they are therefore formed constantly within the body, either in health or disease, however probable such a conclusion might be. But positive evidence that such a formation of alkaloids does occur in the intestine is afforded by the fact that alkaloids are found in the freshly voided fæces.

That alkaloids are present in the circulating blood, is shown by the fact that they are separated from it by the kidneys, and are found in the urine. The effect of ptomaïnes formed in the body in producing disease has been investigated by Bouchard, who has found that the poisonous activity of human fæces is very great, even when they are quite healthy, and a substance obtained from them by dialysis, produces violent convulsions in rabbits. Bouchard considers that the alkaloids formed in the intestine of a healthy man in twenty-four hours would be quite sufficient to kill him if they were all absorbed and excretion stopped. When the functions of the kidneys are impaired, so that excretion is stopped, uræmia occurs: and to this condition Bouchard would give the name of stercoræmia, because he thinks it due to alkaloids absorbed from the intestines. The nervous disturbances which occur in cases of dyspepsia, and of dilatation of the stomach, he thinks are due to nothing else than poisoning by ptomaïnes. Lépine and Mollière describe the case of a man suffering from intestinal constriction, who suddenly became ill and died in two days with all the symptoms of atropine poisoning, redness of the skin, delirium, dryness of the throat, extreme dilatation of the pupils with loss of reaction to light and rise of temperature. There was nothing to show that the patient had taken atropine or belladonna, and Lépine and Mollière consider that he died from ptomaïnes formed in the bowel and absorbed from it. They found in the contracted intestine a fæcal mass having a particularly bad smell, and they think that it was the source of the poisoning.[1] There seems to be little doubt that the amount of ptomaïnes formed in the body in disease is greater than it is in health; and very probably they are of a different character, possibly varying with the disease. According to Lépine and Guerin the poisons contained in the urine in different diseases differ in their physiological action. The extract obtained from the urine in cases of typhoid produced in frogs increased reflex action and death after three hours, the heart being usually found in a state of diastole.

[1] *Lyon Méd.*, No. 42, 1881.

In cases of pneumonia the urine had a similar action, except that the heart was found in a more or less contracted state, varying with the severity of the case from which the urine had been obtained.[1] One author has gone so far as to consider that the immunity which one attack of an infective disease confers against a subsequent one, is due to alteration in the body, not by bacteria, or other low organisms, but by a chemical substance which they produce; and he has proposed to afford protection against the disease by cultivating the bacteria artificially and inoculating with the poison which they produce without the bacteria themselves. This does not seem a very promising method of treatment, but we are likely to obtain most useful information regarding the proper diet in disease, and especially in cases of intestinal disease, by observations on the nature of the poisons which bacteria produce when cultivated in different kinds of food.

This investigation has been begun by Brieger, who found that the typhoid bacillus, although it grew well in peptone, appeared to form no alkaloids from it—at least he was unable to obtain any. When he cultivated it in beef-tea, however, he obtained as a product of decomposition an exceedingly small quantity of ptomaïne, which had a marked peculiarity in its action, namely, that after death from it the heart was found constantly in a state of systolic contraction, whereas most of the other alkaloids obtained from putrefying substances, such as muscarine, tend to produce stoppage of the heart in diastole. This alkaloid when given to guinea-pigs caused slight salivation and increased rapidity of respiration; later on the animals lost control of the muscles of the extremities and trunk, although there was no definite paralysis of the muscles themselves. The pupils became dilated and no longer reacted to light, salivation was profuse, and there was constant diarrhœa; the respiration and pulse became slower, but sometimes the animals did not die until after twenty-four or forty-eight hours. On *post-mortem* examination, in addition to the systolic contraction of the heart already mentioned, hyperæmia of the lungs was found, but the other organs were pale. The intestines were firmly contracted, and their walls were pale. Most of the alkaloids which have been obtained by the decomposition of albumen appear to belong to the muscarine type, and to have a tendency to cause diarrhœa, although some appear to belong rather to the atropine type, which, to a certain extent, counteracts the effects of muscarine.

[1] *Lyon Méd.*, No. 24, 1884.

No alkaloid having a well characterised chemical formula appears as yet to have been isolated from cholera stools, but Nicati and Rietsch[1] have produced choleraic symptoms in animals by cultivations of the comma bacillus from which the bacilli themselves had been removed; and somewhat similar results were obtained several years ago by Lewis and Douglas Cunningham with cholera stools, in which any organisms present had been destroyed by boiling. In view of the extraordinary activity of some of those alkaloids, we cannot wonder at the violent symptoms which sometimes occur after the use of tainted meat, nor even at the extraordinary poisonous action of eggs in some persons. It is probable that the diarrhœa and vomiting which are produced by tainted meat, are due to the poison formed from the albuminous substance of the meat, by low organisms, either before it has been consumed, or by decomposition in the intestinal canal itself. In most persons eggs are harmless, but the yolk of eggs contains, in considerable quantity, lecithin from which choline may be readily formed; and if we suppose that in certain individuals choline, or perhaps even muscarine, is formed from eggs during digestion, we can readily see why this useful article of diet should prove to such persons a violent poison. It is more difficult to say why milk should, in some persons, prove poisonous. Milk also contains lecithin, but in small quantity; and all we can say about it at present is that, in some individuals, a poison is probably formed from it, which causes it to disagree.

But even when milk and eggs do not cause any immediate disturbance of the digestive functions, they sometimes produce, when taken for several days together, a condition which is generally termed biliousness. It is rather hard to define this condition, inasmuch as the term is an elastic one and includes a number of symptoms. Amongst them may be said to be a tendency to eructation and acidity with an appetite which sometimes is very good, sometimes is bad, and sometimes is capricious. These symptoms may depend upon the condition of the stomach itself, but they may also be due to derangement of the liver, for all the venous blood from the stomach must pass through the liver on its way to the general circulation, and any obstruction to the hepatic circulation will produce venous congestion of the stomach and consequent disturbance of its functions. But these symptoms are

[1] *Compt. rend.*, xc. 928.

not unfrequently accompanied, or succeeded after an interval of a day or two, by others which point more distinctly to the liver itself, such as slight frontal headache, a sallowness of complexion, a faint yellowish tinge of the conjunctiva, and a bitter taste in the mouth. These are usually attributed to the presence of biliary matters in the blood, the colour of the face and conjunctiva being attributed to bile pigment, and the bitter taste in the mouth to bile acids. But bile acids are not so very bitter—they are rather bitter-sweet, and healthy bile has no bitter taste, so that it seems that the bitterness in the mouth may, with more probability, be attributed to some alkaloid circulating in the blood, and excreted by the salivary glands. Along with this condition we sometimes find that the stools are pale, and then the explanation of the symptoms is easy, for we at once conclude that there is a catarrhal condition of the stomach and duodenum, and that the swollen mucous membrane presents a mechanical obstacle to the flow of bile from the liver. The pressure of bile in the biliary passages is thus increased, and absorption occurs. This explanation seems so satisfactory that we hardly care to look for another. But it is quite possible that it is not the true one. The real cause may be that the bile has become so viscid that it will not flow through the ducts, and even when the tendency to secrete such thick bile has passed away, the viscid bile already formed may plug the ducts and cause the jaundice to continue, even though the mucous membrane of the ducts and duodenum should be healthy. Moreover, we sometimes find that instead of the stools being paler than usual they are darker than usual, and it seems rather hard to say why we should have more bile than usual passing out into the intestine, and at the same time have bile absorbed into the blood. But here we gain much information from observations on the action of poisons. Schmiedeberg noticed that toluylendiamine, a substance belonging to the aromatic series, produced jaundice ; and the action of this substance has been further investigated by Stadelmann. Their observations show that this poison causes increased destruction of blood corpuscles in the liver, with increased formation of bile. At first all the constituents of the bile, both the solids and the water, are increased, so that a greater quantity of bile is secreted ; but as the action of the poison goes on the solids are excreted in greater quantity than the water: and so along with a great increase in the biliary solids secreted, the bile itself becomes more

and more viscid, until at length it will not flow through the bile ducts, and thus absorption and jaundice takes place—although there is no mechanical obstacle to the passage of the bile into the duodenum. The first stage of the action of this poison corresponds to the condition of biliousness with excess of bile in the stools. It is possible that the second stage may correspond to so-called catarrhal jaundice, especially in epidemics, though it is also possible that the usual explanation of the causation of catarrhal jaundice may be in many cases the correct one.

It is proboble that other bodies belonging to the aromatic series have also a considerable action on the biliary secretion, for salicylate of soda is a powerful hepatic stimulant, greatly increasing the secretion of bile. Unlike toluylendiamine, however, it greatly increases the water of the bile, and renders it thinner instead of more viscid. We do not as yet know what the action of the aromatic compounds formed in the intestine is upon the secretion of bile, but we know that a number of aromatic compounds are formed in the body and are excreted in the urine. These bodies are formed both in health and disease, and carbolic acid occurs in the urine of healthy men. It becomes much increased when the peristaltic movements of the intestine are interfered with;[1] and occurs also in much larger quantity than normally in some cases of infective disease, such as diphtheria, facial erysipelas, pyæmia, and scarlet fever.[2] So far as I know toluylendiamine has not been obtained as a product of albuminous decomposition; but another substance having, like it, the power of producing intense jaundice has been got from lupine seeds. Sheep fed upon these seeds frequently die, and one of the most marked symptoms is intense jaundice. From these seeds Kühne[3] extracted a substance to which he gave the name of ictrogen; and this substance has been further purified by Arnold and Schneidemühl, who give it the name of lupintoxin. It does not appear to be an alkaloid; but rather a substance of an acid nature, but what its exact chemical nature is, has, so far as I know, not been exactly ascertained.

Along with biliousness we frequently find headache, and many severe headaches associated with vomiting are popularly known as bilious headaches. Modern pathology is inclined to regard the

[1] Salkowski und Leube, *Lehre vom Harn*, p. 143.
[2] Brieger, *Weitere Untersuchungen über Ptomaïne*, p. 70.
[3] Quoted by Kobert, *Schmidt's Jahrb.*, 1884, cciv. p. 13.

so-called bilious headaches as rather of nervous than of hepatic origin, and no doubt they frequently originate in mental conditions such as worry and overwork, and also in defective vision. Still, we are but very imperfectly acquainted with the links which connect excessive worry with pain in the head and vomiting: and I think it is probable that here, as in many other cases, popular opinion is based to a certain extent upon truth. Lately, during the epidemic of cholera in Spain, we have heard the same cry raised as in the Middle Ages, that the wells were poisoned, and the popular belief of the Middle Ages coincides with the result of modern scientific research in pointing to contaminated water as the source of disease, although the poisoning is due to the ignorance or carelessness which allows sewage to enter the wells, and not to the direct introduction of poison by design. Similarly popular belief in regard to headaches is, I think, not entirely mistaken in giving to them the term "bilious," for while they may originate in the central nervous system, the liver may play a not unimportant part in their actual production. In the case of a lady who consulted me a short time ago, I was a good deal struck by her observation, that she was always better after the vomiting although she brought up no bile whatever, and she was puzzled to know how the mere action of vomiting could do good. Her observation to a certain extent corresponds with my own experience, and I am inclined to believe that the relief experienced after the vomiting may be due, in part at least, to the emptying of the gall ducts by the compression which the liver undergoes between the diaphragm and the abdominal walls in the act of emesis. The pressure under which bile is secreted is normally very low, and it is easy to see that if the bile should from any reason be more viscid than usual, mechanical pressure would be exceedingly useful, by tending to press the viscid bile, along with any alkaloid it may contain, out of the liver into the duodenum, and thus to prevent its re-absorption.

I do not mean to accuse the bile of being the primary factor in the production of bilious headache. I should be inclined to look upon it more as an accessory, and to attribute the symptoms rather to the presence in the bile of some alkaloidal substance which, on passing into the general circulation, gives rise to vascular disturbance and headache.

We must look to further observations upon the nature of the alkaloids formed by putrefaction; upon the effect of typhoid and other bacilli, on milk, eggs, beef-tea, and other foods used in

typhoid fever, to a more exact investigation of the alkaloids formed in the intestine and found in the fæces and urine, and to experiment upon the action of aromatic substances formed in the intestine upon the liver, for further knowledge which may aid us in treating disease, but enough has been already done to show what important effects on the animal body are in all probability produced by the alkaloidal products of albuminous decomposition.

INTRODUCTORY REMARKS ON THE STRUCTURE AND FUNCTIONS OF THE KIDNEY.

(‘*The Practitioner*,’ VOL. XXVII., *August*, 1881.)

THE progress of physiology and histology in recent years has been so rapid that it is difficult for men engaged in practice to keep up with it, and in addition to this difficulty there is yet another, viz. that the great majority of men are unable to retain, unimpaired, the knowledge which they have at one time acquired, unless they are constantly refreshing their memories. Thus it may happen that men who have been for a length of time engaged in practice may not be acquainted with the points in the histology of the kidney which have been discovered of late years, and that others, who have learned these, may have forgotten them. In order to save such practitioners the trouble of referring to special text-books on histology, I have thought that a few notes on the histology of the kidney may not be amiss.

The function of the kidney is to separate from the blood the products of nitrogenous waste, as well as excess of salts, and various soluble substances which may have passed into the circulation. These are excreted in the form of a watery solution which is the urine. The blood which is to be purified passes to the kidney through the renal artery, and returns, purified, from it by the renal vein, and the products of waste pass out through the ureter. These structures enter into or pass out of the kidney at the hilus. The whole organ is covered by a closely-applied fibrous coat, which in the healthy kidney can be readily stripped off. The kidney may be looked upon as a large filtering apparatus, and the funnel into which the filtrate drains is the ureter. The upper end of the ureter is expanded so as to form the pelvis, and into this funnel-like dilatation the filtering apparatus of the kidney

projects in the form of small pyramids called the medullary pyramids, or the pyramids of Malpighi. The parts of the pelvis which lie between these are termed the calyces, or infundibula. The substance of the kidney itself consists of two parts—the cortex and the medulla. The medullary part has been again subdivided into the boundary layer or marginal layer, and the papillary layer.

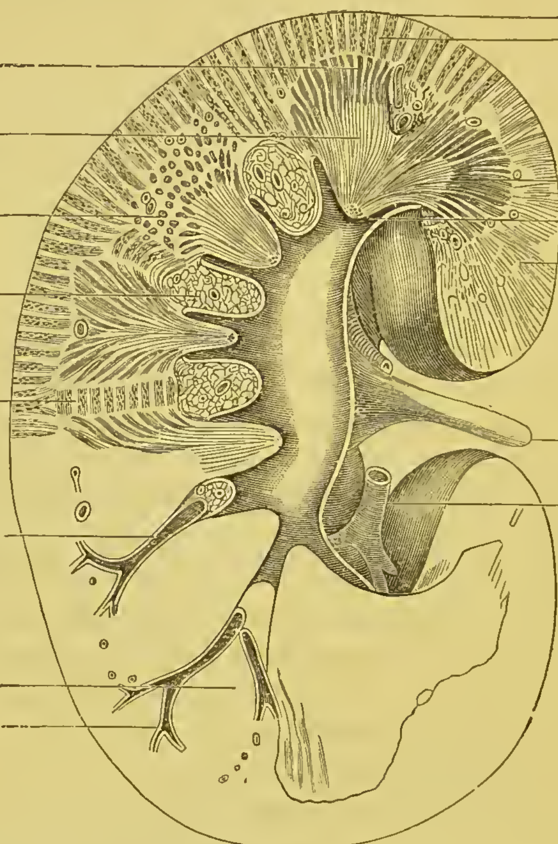

Fig. 32.—Longitudinal section through the kidney. (Modified from Tyson, after Henle.)

When a section of the kidney is made, the cortex is seen to be of a light red colour, and of a granular appearance. It is on an average a little less than a quarter of an inch in width, and dips inwards into the medullary part, so as to divide the pyramids from each other. These prolongations of the cortex are called the columns of Bertin. The pyramids are darker in colour than the cortex, but striated instead of granular. The apex of the pyramid, to which the name of papilla has been given, projects into the pelvis, while its base is in contact with the cortex. The striæ radiate from the apex to the base. These striæ indicate the

course of the urinary tubules and of the blood-vessels. The apical portion or papillary portion of the pyramids is somewhat

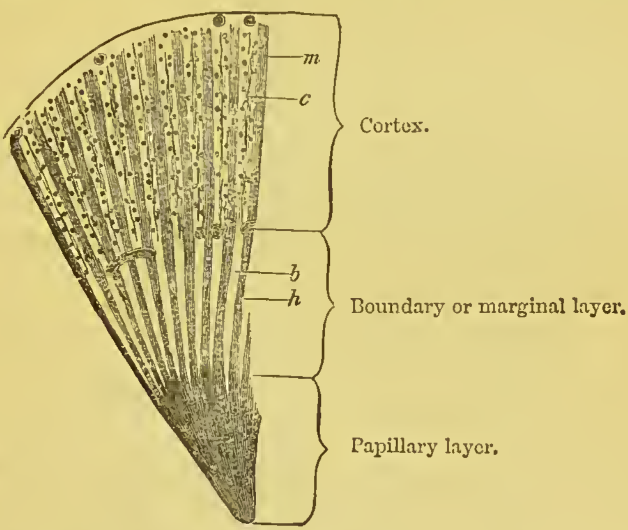

Fig. 33.—Horizontal section of kidney of dog (after Ludwig) :—*h*, fasciculi of urinary tubules prolonged as medullary rays; *m*, into the cortex; *b*, blood-vessels; *c*, cortex proper, with glomeruli.

lighter in colour than the basal portion, and in it the striæ are

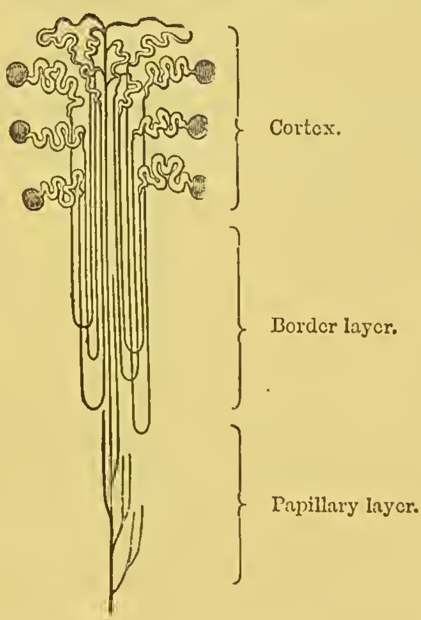

Fig. 34.—Diagram of the course of the uriniferous tubes, showing what parts of them occur in each layer of the kidney-substance.

chiefly urinary tubules, the openings of which may be seen on the papilla. In the basal part of the pyramids, or boundary layer, the

striæ are not uniform, but run in alternate bands, and these bands indicate that this part of the pyramid is no longer uniform in composition like the papillary portion. The difference between the papillary and boundary layers is due partly to the presence of blood-vessels in much larger number in the medullary layer, and partly also to the uriniferous tubules being now no longer uniform in character. This want of uniformity is due to the presence in the boundary layer of portions of the urinary tubules which have come down into it from the cortical layer, and, after forming in a bend or loop, return back to the cortical layer before finally redescending. To these portions the name of Henle's loops has been given. In the medullary layer both tubules and blood-vessels have a straight course, and thus give a striated appearance to the kidney structure.

In the cortical substance both the renal tubules and the blood-vessels have a convoluted course, and the blood-vessels form numerous tufts which give a granular appearance to the cortical substance. This arrangement is seen in Figs. 33 and 34.

But the cortex is not entirely granular. It consists of alternate bands of granular and striated substance (*c* and *m*, Fig. 33). The striated bands, to which the name of medullary rays or pyramids of Ferrein has been given, are composed of straight uriniferous tubules, surrounded by a longitudinal meshwork of capillaries, Figs. 30 and 32. These straight tubules consist partly of collecting tubes on their way to the papilla, partly of the ascending and descending parts of Henle's loops, and partly of certain convoluted tubules, which instead of forming Henle's loops pass straight down towards the papilla (Rose). To the granular bands (*c*, Fig. 33), consisting of convoluted tubules and vessels, the name of labyrinth, or cortex proper, has been given.

The vessels of the kidney are large in proportion to the size of the organ, and it is to be borne in mind that instead of the arteries subdividing near the hilus, as one might imagine, and then running out towards the cortex, they run outwards between the pyramids as far as the inner surface of the cortex before they divide (Fig. 35). At the junction of the cortical with the medullary substance of the kidney the arteries divide and subdivide, forming arches between the cortical and medullary parts. From these are sent off branches, some running outwards towards the surface, and some inwards towards the pelvis. Those running outwards are termed interlobular arteries, and those running inwards are called

the *arteriæ rectæ*. From the interlobular arteries branches are given off which, after a short course, break up into capillary tufts

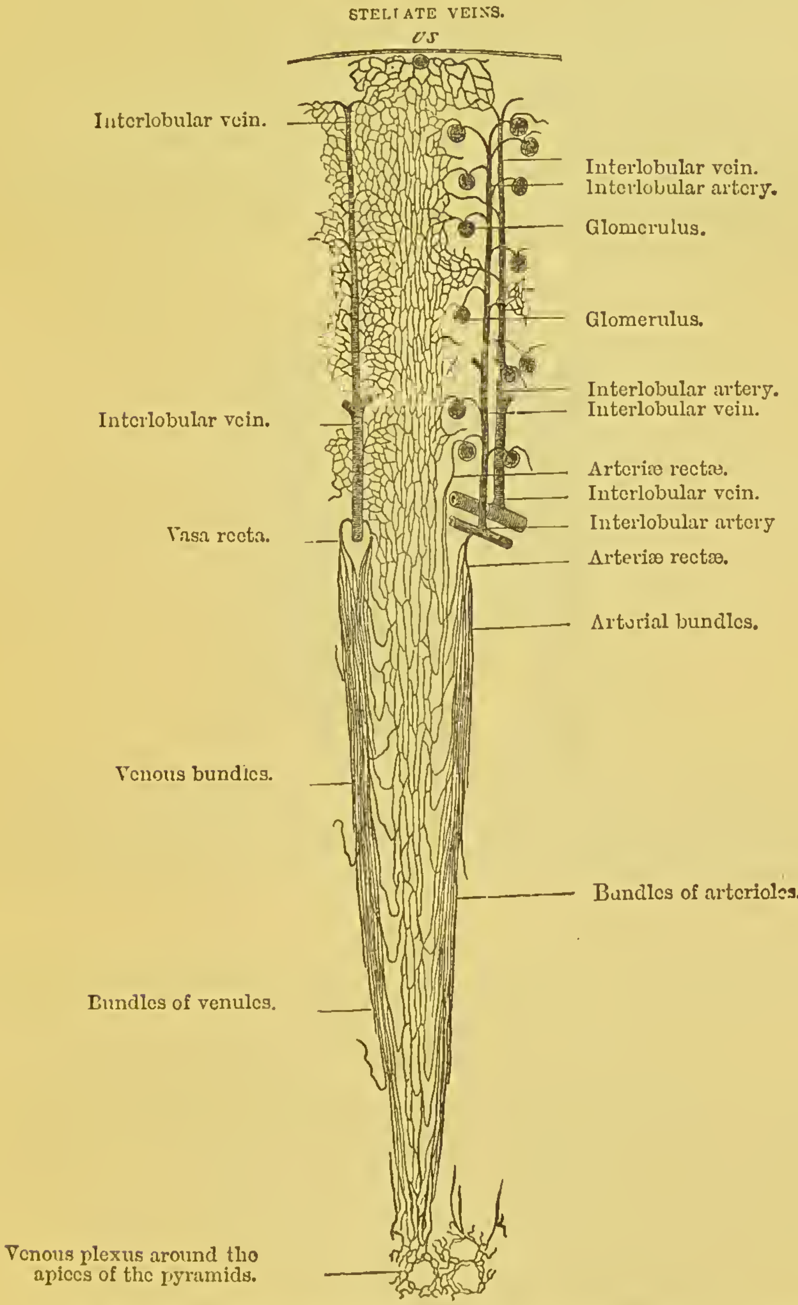

Fig. 35.—Diagram of the blood-vessels in the kidney (after Ludwig).

or knots known by the name of Malpighian tufts or glomeruli. The branch going to the tuft is called the afferent artery (*va*, Fig. 36), and the branch going from it, the efferent artery (*ve*, Fig. 36).

The efferent artery, almost immediately after its exit, breaks up into a capillary mesh-work (Figs. 30 and 32), spreading around and among the tubules. From these capillaries the blood is collected by small rootlets which anastomose to form the interlobular vein, which runs backwards parallel with the interlobular artery. The vasa recta lie between the uriniferous tubules, running parallel with them. They partly form loops like Henle's uriniferous tubules in form, and partly break up into capillaries, forming an elongated mesh-work from which veins arise, and run back parallel with the arteries (Fig. 35).

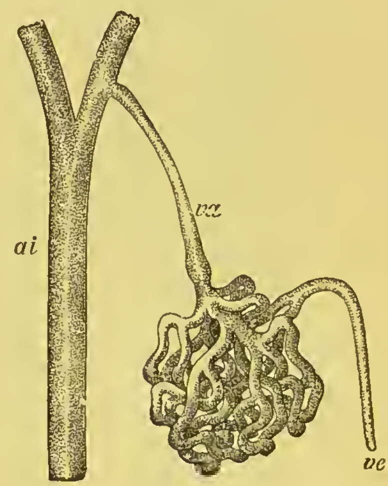

Fig. 36.—Malpighian glomerulus. *va* is the afferent vessel which springs from the interlobular artery *ai*, and breaks up to form the glomerulus; *ve* is the efferent vessel which conveys the blood from the glomerulus.

The kidneys, as we have already said, are a filtering apparatus for the separation of water and soluble matters from the organism. But they are not simply filters, for they have to remove certain substances while they retain others, and to remove those in different quantities and different proportions according to the wants of the organism. There is, then, in the kidney, one part which seems to be devoted to pure filtration, namely, the glomeruli, and another whose function is secretion, viz., the uriniferous tubules. The vessels of the Malpighian tuft are surrounded by a capsule, from which a long, excretary tube leads (Fig. 37). The tuft of vessels may be compared to a porous filter, and the capsule to a funnel, in which the filter lies, and which drains away the filtrate. It has been supposed by Ludwig that the secretion of urine is chiefly a process of filtration, the fluid which drains out of the vessels into

the capsule of the Malpighian body, containing all the elements of the urine, and that the change which this fluid undergoes in its passage down the uriniferous tubules is simply one of concentration, a considerable portion of the water and some of the solids being re-absorbed by the epithelial cells lining the tubule. It has now been shown, however, by Heidenhain, that this view is not quite correct, and that the fluid excreted by the Malpighian tuft is to a great extent water, with, perhaps, a few salts, while certain solid ingredients are excreted by the epithelium of the tubules. The

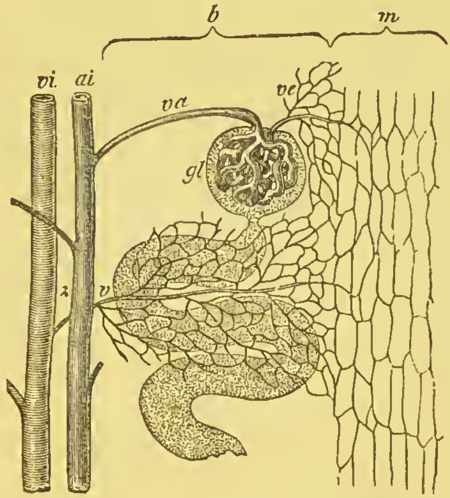

Fig. 37.—Diagram showing the relation of the Malpighian body to the uriniferous ducts and blood-vessels (after Ludwig). *m*, medullary ray or pyramid of Ferrein; *b*, labyrinth or portion of cortex with tortuous tubules; *ai*, interlobular artery; *va*, afferent vessel; *gl*, glomerulus; *ve*, efferent vessel; *zv*, venous twig; *vi*, interlobular vein.

tubules, as might be expected from their complicated function, possess a somewhat complicated structure. They not only vary in width at different parts of their course (Fig. 38), but the epithelium lining these different parts is also different. From the capsule surrounding the Malpighian tuft, often known as Bowman's capsule, the tubule passes off. At first it forms a constricted portion or neck, then it becomes dilated and very tortuous, and runs more or less transversely towards the adjacent medullary ray. It is known at this point by the name of the proximal convoluted tubule. It now runs downwards and is called the spiral tubule of Schachowa. It next becomes greatly constricted, and runs in a straight course down through the boundary layer, into the papillary layer, and here, bending suddenly upon itself and forming Henle's loop, it turns back and again ascends into the cortical layer. The

descending part of this loop is very narrow and straight. The ascending limb of the loop is more dilated and winding, and becomes more or less spiral. As it ascends it becomes wavy, then irregular in outline (irregular tubule), and again dilated and

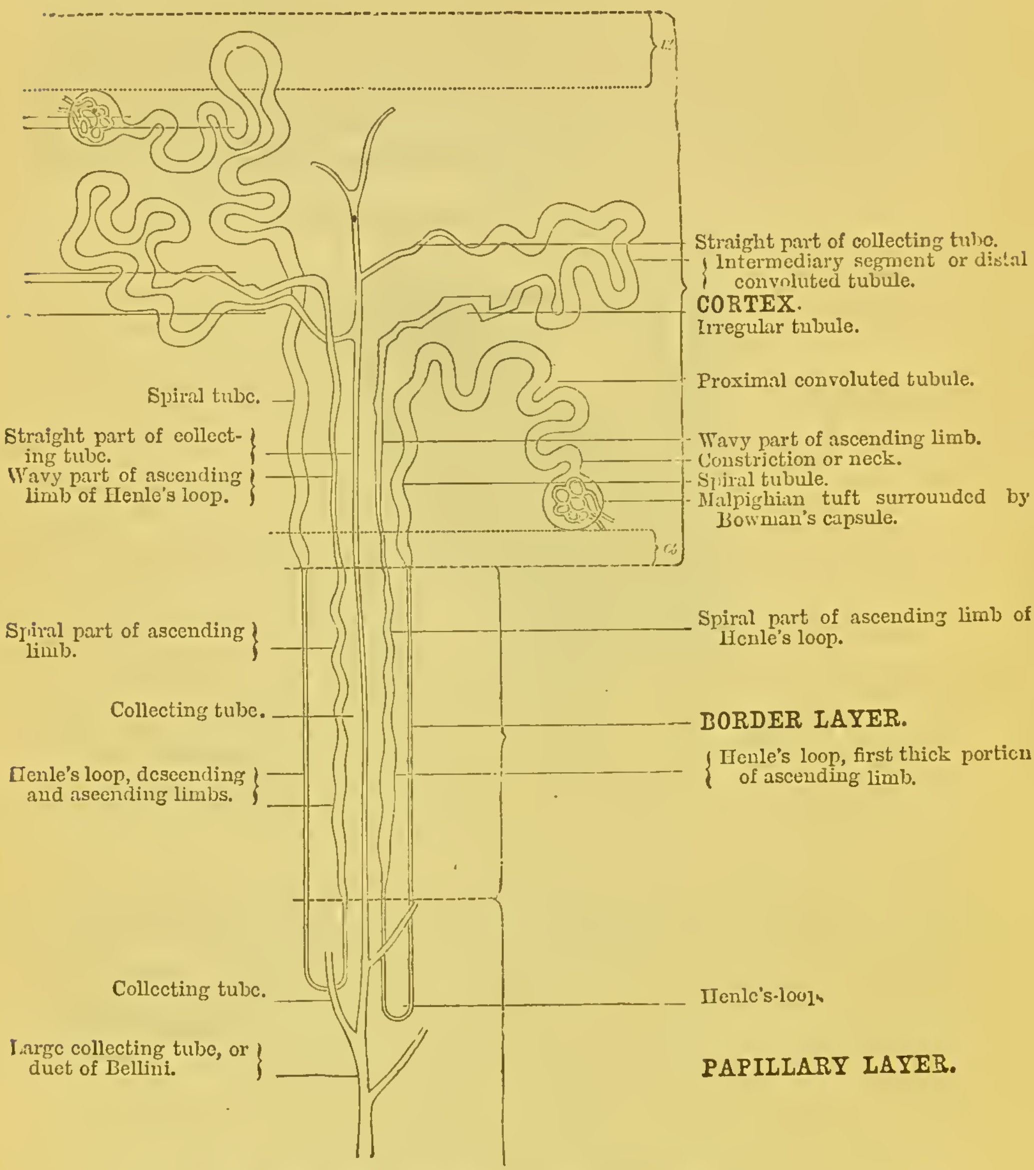

Fig. 38.—Diagram of the course of the uriniferous tubes (after Klein).

convoluted. This second dilated or convoluted part is called the intermediary segment, or distal convoluted tubule. Beyond this the tube again becomes constricted, and joining with others, forms a collecting tube. This in its turn joins with others to form the

large collecting tube, or tube of Bellini, which opens into the pelvis at the papilla. The epithelium lining these different parts

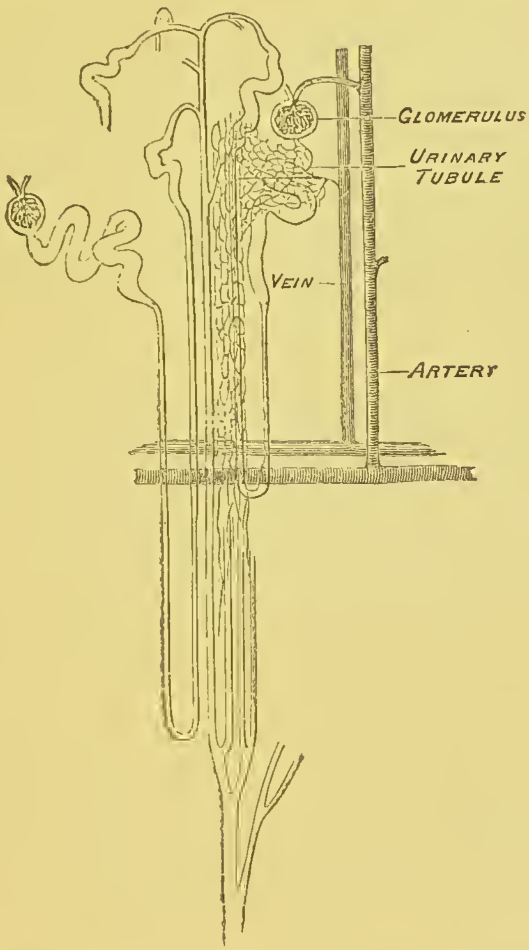

Fig. 39.—Diagram showing the relation of uriniferous tubes and blood-vessels.

is, as I have already said, varied in structure. The cells covering the glomerulus and lining Bowman's capsule are squamous, those of the proximal convoluted tubule are short polyhedral, columnar, or club-shaped. In the spiral tubule they are also polyhedral, and have a tendency to fibulation. In the descending limb of Henle's loop they are flattened, in the ascending limb polyhedral, but flattened and fibulated. In the irregular tubule they vary according to the thickness of the tube, and are polyhedral, pyramidal, or short columnar. The distal-convoluted tubule has a structure exactly like that of the proximal convoluted tubule. The collecting tubes have transparent polyhedral cells whose size varies

according to that of the tubules. Around the tubules is a net-work of capillaries (Figs. 37 and 39), the blood in which plays, no doubt, a very important part in the processes of secretion which occur in the various parts of each tubule. Between the tubules there is a net-work of lymph spaces, which communicate freely with each other, as well as with the lymphatics on the surface of the kidney, and those which issue from the hilus along with the blood-vessels. Between the tubules and the vessels, also, a small amount of connective tissue is found, and a number of small nerve filaments derived from the renal plexus and the smaller splanchnic nerve accompany the final branches of the arteries.

SYMPTOMS, PATHOLOGY, AND TREATMENT OF ALBUMINURIA.[1]

(*'The Practitioner,'* VOL. XV., *Nov. and Dec.*, 1876.)

A VERY large proportion of the patients that medical men in large towns are called upon to treat present symptoms of anæmia or want of blood.

They are pale and washed-out-looking, their whole appearance being apt to recall the blanched look of a washerwoman's hands, and when we examine the gums and the inside of the lips, or pull forward the lower eyelid, and look at its inner surface, we find that all the mucous membranes are paler than in health.

When we come to question the patients, we find that they complain of the very symptoms which we might *à priori* predicate from the condition of the blood. As it is frequently convenient to be able to tell the patient what he or she feels, we will run over in order the symptoms of which persons suffering from anæmia usually complain. First of all, the use of the blood is to nourish the tissues generally, and the muscles among the rest. If the blood be defective either in quantity or quality, the tissues will be insufficiently nourished, the muscles will be unable to do their ordinary work, and the patient will complain of being weak and easily fatigued.

Secondly, the blood has to act as a carrier of oxygen from the lungs to the tissues. All muscular work, all secretion from glands, in fact we may say, every process of life is a process of combustion. Whenever the supply of oxygen fails the work is lessened, and at length stopped entirely, just as the exclusion of air would extinguish the fire in a furnace, and bring to a complete stand-still the engine to which it furnishes the motor power.

Now the combustion in the body goes on at a great distance

[1] Read before the Abernethian Society at St. Bartholomew's Hospital.

from the outer air, and it would stop for want of a sufficient supply of oxygen were it not for the hæmoglobin of the blood. The hæmoglobin is the red colouring matter of the blood, and is contained in the red corpuscles alone. When they are deficient it is deficient, and its chief function and theirs is to act as a carrier of oxygen. It takes up this gas in the lungs, carries it to the tissues, and then gives it up to them. At each breath that a man takes he saturates a quantity of the hæmoglobin in the blood-vessels of his lungs with oxygen, and then on it goes to his muscles to keep up combustion in them. If he is running, leaping, rowing, or using his muscles much in any way whatever, they must get more oxygen than when he is sitting or lying, and in order to give them as much as they need he must breathe much oftener than usual. By doing this, a healthy man can get enough oxygen to enable him to make great exertions, and if his work is only moderately hard he scarcely feels that his breathing is different from usual. But if he unfortunately happens to have a quantity of fluid in his chest, so that one lung can only expand to half the size it ought to do, he cannot take in the proper quantity of oxygen at each respiration. He is therefore obliged to breathe oftener, so as to make up for the small quantity of air that he can take in each time, and so a moderate exertion will make him puff and blow like a healthy man after a hard run.

Now, exactly the same thing takes place when a person has too little hæmoglobin and red blood corpuscles as when he has too little available lung tissue. It is easy to see this. If a man has only half the quantity of hæmoglobin in his blood that he ought to have, it can only take up about half the amount of oxygen that it ought to do, and there is not much to choose between this condition and the case where only one lung is working, and thus giving only half the proper quantity of oxygen to the blood. If the blood only *takes* half the right quantity of oxygen, it is much the same as if it only *gets* half the right quantity.

Thus it is that anæmic persons are short of breath, and if they go quickly up-stairs, they puff and blow so that they cannot speak when they get to the top, and, in short, they are incapable of any great exertion.

Thus the first symptom of anæmia, not to mention the pallor, is muscular weakness; the second is shortness of breath.

The third symptom, or set of symptoms, refers to secretion. As I have already said, secretion is a process of oxidation

as much and perhaps even more than muscular contraction. Ludwig[1] and Spiess found that the saliva secreted by the submaxillary gland of a dog was actually $1\frac{1}{2}°$ C. warmer than the blood of the carotid artery, and of course to heat the saliva in this way there must be very active combustion going on in the gland during the process of secretion. To supply the oxygen required for this combustion, the arteries of the glands are found to dilate, and torrents of bright-red oxygenated blood rush rapidly through them. Nor is this process confined to the salivary glands alone. The stomach, the pancreas, and probably also the intestines, all get a copious supply of arterial blood during the process of secretion, and although a rise of temperature indicative of active combustion has not been demonstrated to take place in them during the act of secretion, it is in the highest degree probable that these other glands resemble the salivary ones in this respect. Seeing, then, that oxidation plays such an important part in secretion, we could hardly expect that it would go on briskly, any more than that the muscles would work easily, when the blood is poor in hæmoglobin, and the supply of oxygen which it ought to convey to the glands is consequently deficient.

Now the whole process of digestion depends on secretion, and if the salivary glands and pancreas do not secrete properly, the starchy part of the food will not be rendered soluble; if the stomach does not pour out gastric juice, the albumen and fibrin will not be digested; and if the pancreas is not working, the fats will pass out unchanged. And even when these organs do their work after a fashion and succeed in digesting the food at length, yet if they secrete their appropriate juices in small quantity the food will be only slowly digested. It will then undergo partial decomposition in the intestine instead of being rapidly dissolved, and will give rise to the formation of gas in the intestines with all its attendant discomforts. The symptoms of this condition are —there is no appetite, the food lies heavy at the stomach, and there is frequent belching of gas which often brings up with it particles of undigested food or sour burning liquids. There is often nausea, sometimes retching, or vomiting. The bowels are sometimes very loose and at others very confined.

We may thus add to muscular weakness and shortness of breath a third symptom of anæmia, viz. *dyspepsia.*

Having thus found that the muscular, respiratory, and digestive

[1] Ludwig's *Physiologie*, vol. ii. p. 341.

functions are all impaired by anæmia, we naturally inquire how the nervous system gets along. The brain cannot work without oxygen any more than the muscles; indeed it requires a still more constant supply than they, and when we direct our attention to it we find that it enjoys no exemption from the general debility. Deficiency of motor power manifests itself in languor, listlessness, and laziness, while the sensory functions evidence their disturbance by giddiness, drowsiness, headache, weight in the head, throbbing of the arteries, neuralgic affections, and numberless odd nervous symptoms, which lead medical men who are themselves suffering from anæmia to believe that they have all sorts of mischief going on within their brain-pan, until a little quassia and iron removes their symptoms and allays their apprehensions.

We come lastly to the circulation, and we find that it too suffers, so that although we have put it last, one of the symptoms connected with it sometimes attracts our attention more than all the others together. This symptom is *œdema* or swelling from the presence of fluid in the cellular tissues.

How does this fluid come to be there? During life there is a constant exudation of fluid from the blood-vessels, and after this has done its work by affording nutriment to the cells of which these tissues are composed, it is again absorbed, partly by the veins and partly by the lymphatics. In health the exudation and absorption balance each other, and so there is no accumulation of fluid in the tissues; but whenever the exudation becomes too rapid, or the absorption becomes too slow, such an accumulation takes place. When it occurs in the tissues it is called œdema; when in a large lymphatic space, better known perhaps by its more common name of serous cavity, it is termed dropsy.

Now absorption has been shown by Goltz to depend very much on the vaso-motor nerves.[1] When these are acting powerfully, absorption takes place rapidly; when they are acting slightly, absorption takes place slowly.

Deficient action of these nerves also causes fluid to be poured out more rapidly from the vessels,[2] as well as to be absorbed more slowly. Thus any weakness of the vaso-motor system tends to produce œdema in a double fashion, and to such weakness we may probably ascribe the œdema we meet with in anæmia. It

[1] Pflüger's *Archiv.*, vol. v. p. 33.

[2] Ranvier. *Recherches Expérimentales sur le Production de l'Œdème, Comptes rendus*, 1869.

is quite evident that if the œdema is dependent on deficient re-absorption, we shall find it most marked in those parts where the circulation in the veins and lymphatics is most languid—*i.e.* in the feet and ankles; and this is indeed what we do find in œdema depending on venous obstruction; but when it depends on excessive exudation also, it may be found wherever the tissues are loose, as in the lower eyelid and scrotum. In health the vaso-motor nerves keep the arterioles throughout the body more or less contracted, and thus prevent the blood which the heart pumps into the aorta from running out quickly into the veins. They thus keep the arteries always well filled and fairly on the stretch, so that the heart cannot stretch them still more by emptying itself into them, without using a fair amount of force. But when the vaso-motor system gets weak, it no longer keeps the arterioles up to their work, and in consequence they occasionally dilate and let the blood through them more quickly than they ought. The arteries consequently get partially emptied; the heart can pump all the blood into them with almost no exertion, and so it sometimes seems as if it did not know what to do with its superabundant energy, and works fast and loose like the driving-wheel of a locomotive on a piece of greasy rail. Another symptom of anæmia is, therefore, *palpitation.*

We may now at last count up on our fingers the symptoms of anæmia, not reckoning, but always bearing in mind, the pallor of the patient. We have (1) muscular weakness; (2) shortness of breath; (3) dyspepsia; (4) weakened nervous system, both sensory and motor; (5) weak circulation leading to palpitation, and œdema or dropsy.

All the varied symptoms included under these five heads may, as we have seen, be caused by anæmia, though we must not forget that some of them may be present without anæmia. For example, an individual may come complaining of dyspepsia, though a single glance at his plethoric countenance shows you that no want of blood is the cause, but rather gourmandizing and gluttony above the powers of even the most healthy stomach to sustain. But supposing we have all the symptoms included under the five heads just given, and the pale face and blanched mucous membranes leave no doubt on our minds as to the presence of anæmia, we have next to ask what is the cause of it, in order that, instead of trying to remedy one symptom by itself and another symptom by itself, we may strike at the root of the disease and remove the anæmia on which they all depend.

There are two ways in which a man may come to want money; (1) he may not get enough to supply his daily wants, either from laziness or misfortune; or (2) he may lose what he has either by being extravagant and squandering until poverty compels him to tighten his purse-strings—steadily living above his income, and thus losing his fortune by degrees; or by rashly speculating, and thus losing a great part of it at one stroke.

And just so it is with the blood. We use up some of it every day to keep our tissues in working order; and unless this loss were regularly compensated by the food we eat our blood would soon be too much reduced in quality, if not in quantity, to sustain life. For be it remembered that a proper quantity of blood will not nourish the tissues if its quality be deficient, any more than an ounce of copper will pay a man's debts when they amount to an ounce of gold. Whenever, then, this nourishment, which is daily received into the blood, is insufficient to supply the daily expenditure on the tissues, anæmia will, in a greater or less degree, be sure to follow. It does not very much matter whether the supply of food taken into the mouth is insufficient, or whether imperfect digestion prevents assimilation. Dyspepsia, then, by lessening the appetite, and rendering the digestion of such food as is consumed less perfect than it ought to be, has much the same effect as partial starvation, and is one cause of anæmia.

But anæmia we have already seen to be a cause of dyspepsia; and thus the one aiding the other they go on from bad to worse, in a vicious circle, unless something interferes to break it.

The cases of anæmia which I would liken to the spendthrift are those of chlorotic girls where the anæmia really seems to depend on some of the organs or tissues using up the blood in a way they have no right to do, and thus squandering the precious fluid without getting any good from it, and indeed without one's being able to see where it has gone, unless the deep-red colour of the urine one gets in such cases on the addition of nitric acid to it may be taken as an indication that more than a fair share of the hæmoglobin of the blood has undergone some mysterious transformation, and found too ready a way of escape through the kidneys.

Anæmia may also be a consequence of sudden and considerable losses of blood, such as those which occur in menorrhagia, or from bleeding piles, which not unfrequently drain away the vital fluid and sap the patient's strength, ere ever he be aware of the mischief which is going on.

Important as these causes of anæmia are, there is yet another no less important, and in which the drain is still more constant, although in it one may not see the blood actually leave the body while still retaining its well-known colour.

This cause to which I wish especially to direct your attention is albuminuria.

In it the blood is constantly losing one of its most important constituents, the albumin, which leaks through the kidneys along with the urine, and thus runs to waste instead of remaining in the body and ministering to its nutriment. Although the serum-albumen thus lost is not a constituent of the red blood corpuscles yet the deficiency in it seems in some way to affect them, and their numbers diminish, possibly, though we cannot say with certainty, because they cannot get the albuminous constituents of their hæmoglobin in requisite quantity. For it must be remembered that the hæmoglobin, or colouring matter of the blood, which plays such an important part in the oxygenation of the tissues, consists of an albuminous substance, globulin, and a non-albuminous substance, hæmatin. There are regulating arrangements in the body which keep all its different parts in mutual harmony and dependence on one another, so that, as St. Paul said long ago, "if one member suffer, all the members suffer with it," and if one part is starved, the other parts frequently, if not always, suffer privation with it. The serum-albumin being, then, deficient in the blood, it is not at all astonishing that the albuminous constituent of the colouring matter should also be below par.

The symptoms of albuminuria are, therefore, those of anæmia, and we often suspect the presence of the disease from the mere look of the patient before we have addressed a question to him or applied a single instrument of physical diagnosis. There is not only paleness from the general want of blood, but there is a greater tendency to œdema than in other forms of anæmia, so that the face is not only pale, but puffy, pasty, or doughy looking, with a tendency to swelling about the lower eyelids. The ankles and shins are frequently œdematous and pit on pressure, and there may also be accumulations of fluid in one or other of the serous cavities. These appearances in a patient at once arouse a suspicion of albuminuria, and we proceed to test them by examining the urine. In a state of health this secretion should be absolutely free from albumen. We detect the presence of this abnormal constituent in two ways: 1st, By boiling; and, 2nd, by adding nitric acid. On

boiling urine containing albumin, coagulation takes place, and according to the quantity present we have either a faint haze giving an opalescence to the liquid, a heavy coagulum, or any intermediate condition between these two. There are some fallacies in this test, however, which require attention, for ignorance of them may lead us to imagine that there is no albumin when it is really present, or to fancy it there when the urine is completely free from it. The first fallacy is that serum-albumin forms compounds both with alkalis and acids, to which the names of alkali-albumin and acid-albumin have been given respectively. Now neither of these compounds are coagulated by heat, and although serum-albumin itself is readily coagulated by boiling, yet if acids or alkalis are present when we begin to heat it, the very warmth of the liquid, as we gradually raise its temperature, causes the albumin to combine with the acids or alkalis and form acid-albumin, or alkali-albumin. Thus it may happen that by the time we reach the temperature at which the albumin should be precipitated it is no longer present in its original condition, its combinations being already complete.

Thus, if the urine be very strongly acid, or very strongly alkaline, we may get these compounds formed, and then heat produces no coagulation, although albumin is present. We therefore ascertain the reaction of the urine by means of litmus paper before applying heat. As the tissues of the body are all alkaline, it is very unlikely that the urine will contain so much free acid as to produce acid-albumin, and indeed such a condition is almost never found except in persons who have been taking large quantities of mineral acids.[1] In such a case we would add sufficient alkali merely to neutralise the acid before we boiled the urine, but this is so rarely necessary that we generally disregard this source of error. Excessive alkalinity, however, is not so uncommon, and we very frequently have to add a few drops of acetic acid to the urine so as to render it slightly acid before boiling.

This addition of acid, however, serves a double purpose, and not only enables us to detect the albumin more certainly when it is present, but prevents us from mistaking other things for it when it is absent.

In some urines alkaline phosphates or carbonates are precipitated by heat and may be mistaken for albumin, but a drop or two of acetic or nitric acid prevents their precipitation, or if added

[1] Stockvis, *Sur l'Albuminurie*, p. 3.

after they have already been thrown down dissolves them again and causes the urine which they have clouded to become clear again.

It is thus evident that heat alone without acid is an insufficient test for albumin. Nitric acid coagulates albumin and causes a haze or coagulum just like heat, but nitric acid alone without heat is also unsatisfactory and may be deceptive. If the urine contain a large quantity of urea, the nitric acid may cause the formation of a crystalline precipitate of nitrate of urea, which is, however, but rarely mistaken for albumin. But if urates be present in large proportion, one is much more likely to fall into error, for the nitric acid drives out uric acid from its combinations with soda or potash, and free uric acid being much less soluble than urates a precipitate is formed which is much more likely than the urea one to be mistaken for albumin. A little heat now applied to the urine causes either urea or uric acid to redissolve, and the urine clouded by them to clear; but it has no effect on the haze or coagulum produced by albumin.

In testing for albumin, then, the best method of proceeding is to allow three or four drops of nitric acid to trickle down the side of the test tube containing the urine. If no haze appears we may conclude that the urine is free from albumin.[1] It won't do to pour in acid until the test tube is half full, for it is possible that if only a little albumin is present it may be converted into acid-albumin and dissolved by the concentrated acid. If a cloudiness appears we must not at once conclude that it is due to albumin, but must warm the urine over a spirit lamp. If it is really albuminous the opacity will remain, but if the cloud is due to urea or uric acid it will disappear.

So much for the symptoms of albuminuria, which are paleness and pastiness of the face, a tendency to œdema and dropsy, complaints of weakness, shortness of breath, dyspepsia, nervous symptoms, and, I may add, occasionally palpitation, associated with the presence of serum-albumin in the urine.

The next thing we have to do is to inquire how the albumin which we find in the urine gets there, and in order to do this we must take a glance at the structure of the kidney.

The function of this organ is to separate the products of tissue waste and any excess of water which may be present in the blood, but at the same time to prevent anything that is of use to the

[1] Stockvis, *Sur l'Albuminuric*, p. 4.

economy from passing through. When we wish to separate two substances, one of which is insoluble and the other soluble, in the laboratory, we use a filter, and we have in the kidney an apparatus for filtration. When we wish to filter rapidly we use a number of filters at once, so as to increase the surface of filtering paper, and if we are in a great hurry we help the fluid through by means of pressure, generally that of the atmosphere, as in a Bunsen's pump.

In the kidney we have something similar, for the renal artery inside the kidney divides into branches, which break up into knots of small vessels, thereby increasing their surface enormously; and the renal artery is extremely wide, so that there is always a considerable pressure on these little vessels compared with what there usually is on small vessels generally. And just as a filter is put in a funnel which collects and conveys away the filtrate, so these bunches of arterioles or glomeruli, as they are called, are enclosed in a little bag or capsule which collects the urine as it exudes through them. But the urine, as it filters through, contains a number of salts which may be utilized in the body, and more water than the organism can well afford to lose. Therefore, before it is excreted it passes through a long winding tube lined with epithelium and dilated at two points, while it is narrow at two others. Thus the fluid finds a difficulty in getting through rapidly, and lies for a while in the dilated parts of the tube, so that the epithelial cells which line them have plenty of time to absorb the superfluous water and the salts, which may again be utilized. But what are the cells to do with this water and salts? How are they to get rid of them? They do so by giving them up to the veins, which form a plexus all round these tubes, and absorb and convey away into the general circulation all that the cells remove from the tubules. It is thought by many, and with great probability, that the cells lining the tubules do not merely absorb from the tubules the water and salts which they give up to the veins, but that they also take from the veins various products of tissue waste, especially urea, and excrete them into the tubules. Between the tubules and veins are lymph spaces, in which both they and the arteries lie, and this fact I wish you specially to remember, as it is of great importance. We may, if we like, look on the kidney as a sac containing lymph, in which the arteries, tubules, and veins are all imbedded, though they are packed so thickly together that we hardly recollect that there is any lymph space there at all; just as when we stuff a lot of tow into a pan of water so as to fill it, we

see only the fibres of the tow and forget that they are lying imbedded in water, which fills all the interstices between the fibres. This will be more evident if we look at the right-hand side of the accompanying diagram (Fig. 39, p. 305), in which the tubules, arteries, and veins, thickly crowded together as they are, may be fairly compared to the closely-packed fibres of a bundle of tow, while all around them is lymph. At the left-hand side of the diagram the capillaries have been omitted so as to show the course of the tubules more plainly. Now, ordinarily, the glomeruli do not let out any albumin, though they allow water, salts, urea, and such like crystalline products to filter out, or possibly it might be more correct to say diffuse out, seeing we have fluid on the outside as well as inside of the arterial twigs instead of air on the outside as in ordinary filtration. But filtration and diffusion seem to be merely varieties of the same process, if we accept the experiments of Moritz Traube.[1] The molecular weight of a body seems, according to him, to represent the size of a single molecule, and a body with a low molecular weight, and consequently with a small-sized molecule, will pass through the minute pores of an animal or vegetable membrane when the big molecules of a body which has a large molecular weight would stick on their way. Thus you know that Graham divided bodies into crystalloids and colloids, because crystals when dissolved generally diffuse easily, while bodies which do not crystallize hardly diffuse at all. But hæmoglobin, the colouring matter of the blood, forms beautiful crystals, and yet it does not diffuse, a fact which seems difficult to explain unless we adopt Traube's hypothesis, and then it is as plain as possible. Most crystals have a low molecular weight, but hæmoglobin has an enormous one, its formula, according to Preyer, being $C_{1200}\ H_{960}\ N_{154}\ F_2\ S_6\ O_{354}$, so that its giant molecules are simply too big to get through the pores of a membrane.

Now serum-albumin, as I have said, does not diffuse through the kidney, but white of egg does, and whenever we inject white of egg under the skin it appears again in the urine, and the same is the case if a man eats more eggs than he can digest. A single raw egg drank before a race is popularly said to give a man wind, but I have heard of a man who, when about to run a race, instead of one, drank eleven eggs, with the result that, instead of improving his wind immensely as he expected, he could not run at all. I have little doubt that if his urine had been examined albumen

[1] *Centralblatt f. d. med. Wissenschaften*, 1866, p. 97.

would have been found in it. When eggs are injected into the rectum also, part of the albumen sometimes remains undigested, but is absorbed and passes out in the urine. Another sort of albumin discovered by Bence Jones, and named after him, passes into the urine in the same way as white of egg.[1]

From these facts, judged in the light of Traube's hypothesis, it would almost seem that the molecular weight of white of egg and of Bence Jones's albumin is less than that of serum-albumin, and that they filter through while the latter is retained. But though the arterial twigs in the glomeruli may allow white of egg to pass, they do not appear ever to allow serum-albumin to exude even under the greatest pressure, unless indeed they should happen to burst altogether, and then not only the albumin, but the blood corpuscles also get out into the urine. The reason for this belief is that even when we tie the aorta below the renal arteries, and thus raise the blood pressure enormously in the glomeruli, not a particle of albumin appears except, as I have already said, it comes along with blood.[2]

But the veins are very different from the arteries in this respect, and a slight increase of the blood pressure within them is sufficient to produce albuminuria. We can easily fancy this when we take a glance again at the structure of the kidney. The tubules are surrounded by lymph, which probably exudes from the capillary net formed by the artery after leaving the glomerulus. So long as the veins are ready to absorb this lymph matters go on smoothly, but whenever the pressure inside the venous radicles is increased by any obstruction in front, the case becomes very different. The lymph cannot get back into the arteries because the pressure in them is too great, it cannot get into the veins for a similar reason, the lymphatics do not seem to be able to carry it all off, and the easiest way of escape is into the tubuli uriniferi, and so out it goes, carrying with it the albumin it contains, and thus producing albuminuria.

Thus any obstruction to the return of venous blood from the kidneys is one of the causes most certain to produce albuminuria. Let us, therefore, follow the course of the renal veins so as to see where any obstruction is likely to occur. First, there may be a

[1] The only practical application to which a knowledge of this kind of albuminuria may be turned is that, if you are feeding weak patients with enemata of eggs, the appearance of albumen in the urine may not be at all an indication of kidney-disease, and researches on this point would certainly be of service to the profession.

[2] Stockvis, *Sur l'Albuminurie.*

tumour pressing on the renal veins themselves or on the vena cava, and this at once reminds us that a pregnant uterus may be a temporary cause of albuminuria. But except from this physiological tumour, we find comparatively few instances of pressure on the veins, and, omitting tumours of the liver, the first cause of obstruction we come to is the heart. Whenever the right side of the heart becomes dilated, and the tricuspid valve incompetent, each cardiac systole drives some of the blood back into the veins, and thus leads to serious congestion of the kidneys. A common cause of albuminuria, therefore, is heart disease.

But tricuspid disease is rare as a primary lesion, and incompetence of this valve is generally secondary to affections of some of the other cardiac orifices, such as the mitral or aortic.

As it is more common in cases of mitral disease, we will consider this first. You will often find patients who have loud mitral murmurs without a trace of albuminuria. So long as the right side of the heart is tolerably strong, it can hold its ground even against the increased pressure it has to overcome, and it is not until it begins to get weak that it relaxes and dilates before the internal pressure until the tricuspid valves no longer suffice to close the enlarged orifice, and regurgitation consequently takes place. The same is the case in aortic disease, only the pressure there has first to overcome the left ventricle and dilate the mitral orifice before it can begin to perform the same operation on the right ventricle and tricuspid valve. Thus it is that venous congestion and albuminuria do not so readily follow aortic as mitral disease.

But any obstruction to the flow of blood through the lungs will produce more or less congestion of the kidneys, and thus lead to albuminuria, although it would appear that the obstruction must be pretty considerable before this symptom appears. Thus we do not find albumen in the urine in every case of pulmonary derangement; but Dr. Parkes has found it temporarily present in considerable quantities in acute pneumonia.[1] In cholera too, where, as is usually believed, the pulmonary vessels contract spasmodically, so as to prevent the blood from flowing through them, we

[1] I am inclined to think, however, that there must be a weakening of the vaso-motor nerves to the renal veins as well as obstruction to the circulation in the lungs, for I have seen a case of great dilatation of the right ventricle and tricuspid incompetence where no albumen appeared in the urine, notwithstanding the great pressure to which the blood in the renal veins must have been subjected by the backward flow from the ventricle.

would expect albuminuria to be present, and so it is—indeed, some have said that the only reliable diagnostic sign between true cholera and other diseases simulating it is the presence of albumin in the urine. If we could produce a similar spasm of the pulmonary vessels reflexly, we would expect a similar result; and Dr. George Johnson has observed a phenomenon which may possibly be due to this cause.[1] Sometimes after bathing albumin appears in the urine of perfectly healthy persons. Now I dare say we have all felt the peculiar constriction about the chest and difficulty of breathing when we walked up to the chest into cold water. We have no proof, so far as I know, that this is due at all to contraction of the pulmonary vessels, and I only suggest it as a possibility; but if these vessels should contract under the influence of an impression conveyed to them reflexly from the nerves of the skin we can at once understand why albumin should appear in the urine in such cases.

One great cause of true albuminuria, then, is *venous congestion.*

The next cause has to do, not with the vessels, but with the tubules. When inflammation of the kidney has occurred, and the epithelium lining the tubules undergoes degeneration and peels off, leaving the walls of the tubules bare, there does not seem to be any reason why the lymph which surrounds them should not filter into them instead of going into the veins; and practically we do find that when the tubules are in this condition the urine is albuminous, just as we would expect.

Having already trespassed too much on your patience, I cannot enter here into the different kinds of kidney disease in which albumin occurs, but I would like to say a word ere closing on the question of treatment.

We have seen that venous congestion causes albuminuria, and will of course increase it, even when it depends on denudation of the tubules. Arterial congestion does not *cause* albuminuria; but if much blood is flowing through the arteries of the kidney there will be more in the veins than if the circulation was less, and consequently arterial congestion, by increasing the pressure in the veins, may aggravate albuminuria already present, although it does not produce it.

The first indication for treatment then is, remove the venous obstruction if you can. The second is, lessen the flow of blood to the kidneys by drawing some of it elsewhere.

[1] *Brit. Med. Journ.*, Dec. 6, 1873, p. 664.

The venous obstruction depending on pregnancy will cease at the time of parturition, but it may be diminished by the prone position, while that depending on cardiac disease may be lessened by the use of such drugs as digitalis, which causes the heart to contract more forcibly, and by thus diminishing its orifices may render its valves once more competent.[1]

The second indication is fulfilled by warm clothing, warm baths, and diaphoretics, which draw the blood to the skin; and by purgatives, which cause a greater flow of it towards the intestines.

The third indication is to lessen the anæmia, which results from the drain of albumen, and of itself produces so many distressing symptoms and injurious effects.

This indication is fulfilled by the administration of iron, which increases the number of blood-corpuscles, and at the same time diminishes the loss of albumen through the kidney. I will not at present attempt to explain how it acts, for this is matter of supposition, and others may be prepared with a more probable hypothesis than I can offer.

The special points to which I have tried to draw attention in this paper are—

(1) The symptoms of albuminuria are those of anæmia, viz.—a pale and pasty complexion of the patient, who, on inquiry, tells you that he is weak, that he is short of breath, and suffers from dyspepsia and nervous weakness; that you may observe œdema of the legs, and you find albumin in the urine.

(2) The modes of detecting albumin.

(3) The causation of albuminuria.

a. Spurious albuminuria due to white of egg, or albumins other than serum-albumin.

b. True albuminuria, in which serum-albumin appears in the urine, and which is due to venous congestion or disease of the tubules.

(4) The treatment of albuminuria.

[1] Digitalis has also a direct action on the renal vessels, which it causes to contract when given in large doses. Brunton and Power; *Proceedings of Roy. Soc.*, No. 153, 1874.

ARSENIC IN ALBUMINURIA.[1]

(‘*The Practitioner*’ *for June* 1877.)

Albuminuria has been divided by Gubler into two sorts, false and true. False albuminuria, according to him, consists in the admixture of pus, or of blood, with the urine. I, however, am inclined to extend the significance of the term false albuminuria, and include in it all those cases where an albuminous body other than serum-albumin occurs in the urine. False albuminuria would thus include not only those cases where pus or blood occurs in the urine, but those in which the so-called Bence Jones's albumin, egg-albumin,[2] and possibly paraglobulin make their appearance. Under ordinary circumstances albuminous bodies do not diffuse through animal membranes, but it has been shown by Bernard, Pavy, Stockvis, and others that albumin of eggs will pass out through the kidneys, while the albumin of blood does not do so under similar conditions. Bernard, it is true, believed that serum-albumin passed through the kidneys in much the same way as egg-albumin when it was injected into the circulation; but Stockvis, having repeated Bernard's experiments, showed that the serum-albumin only appeared in the urine when the experiments had been imperfectly performed, and the injection had interfered with the proper circulation of the blood in the veins, thus causing venous congestion of the kidney itself. Egg-albumin and Bence Jones's albumin he found to be excreted by the kidneys, not only when they were injected into the blood, but when they were introduced under the skin or in large quantities into the rectum.[3] In the two latter cases the interference with

[1] Read before the Medical Society of London.

[2] To distinguish between the entire white of egg or *albumen* and *egg-albumin*, which is its chief but not its only constituent, the former is spelt with an *e* and the

the circulation was obviously not the cause of the appearance of albuminuria. It seems curious that one sort of albumin should pass through the vessels of the kidney, while another should be retained, and the only feasible explanation of it seems to be that the molecule of the different albumins varies in size. For the passage of substances in solution through membranes has been shown by Moritz Traube to resemble very much the passage of powdered matters through a sieve.[1] When the particles of the substance are too large to pass through the meshes of the sieve they are retained, but when they are too small they pass through. Thus almost all crystalline substances readily diffuse through animal membranes, and Graham divided bodies, according to their diffusibility, into crystalloids and colloids. But there is one marked exception to the rule that crystalline bodies diffuse, and this is the colouring matter of the blood, hæmoglobin. This substance differs from most other crystalline bodies in possessing a very high molecular weight, and the molecule is therefore, in all probability, very large. Traube's hypothesis at once explains this curious exception to Graham's law, and renders it probable that hæmoglobin does not diffuse simply because its molecule is too large to pass through the pores of ordinary membranes. We may apply this hypothesis to explain the appearance of albumin in urine after the injection of white of egg under the skin, and its absence after a similar injection of serum-albumin. If we suppose that the molecule of egg-albumin is smaller than that of serum-albumin, we can readily understand that after being absorbed from the subcutaneous cellular tissue, and carried by the blood to the kidneys, it may pass through the vessels into the urine, while the larger molecule of serum-albumin will be retained.

The facts regarding false albuminuria are, that egg-albumin, and other albumins such as Bence Jones's albumin, pass out through the vessels of the kidney without any alteration in the structure of the organ, or interference with the circulation of the blood through it, while serum-albumin will not pass out.

True albuminuria consists in the passage of serum-albumin, which is a normal constituent of the blood, into the urine. It depends either upon alterations in the structure of the kidney, or interference with the circulation through it, or upon both. It has been supposed that great increase in the pressure of blood within the renal glomeruli will cause albumin to appear in the

[1] *Centralblatt d. med. Wiss.* 1866, p. 97.

urine, but the experiments of Stockvis appear to disprove this supposition.[1] He found that no increase in the arterial pressure, either generally throughout the body, or in the kidney alone, would produce it. He raised the general pressure by compressing the aorta and other large arteries, and he raised the pressure in the kidney itself by dividing the vaso-motor nerves of the organ so that the renal arteries dilated and allowed much more blood than usual to pour into the kidney. In neither case did he find any albuminuria, but the result was very different when he interfered at all with the venous circulation of the kidney. An obstruction to the return of the blood through the renal veins was sufficient to cause albuminuria. Thus it came on when the renal veins were tied, when the vena cava was plugged, or when the movements of the heart were interfered with by a small caoutchouc ball passed down the jugular vein into the right ventricle, or when quantities of fluid were injected quickly into the jugular vein. It is to the venous obstruction caused by such injections that Stockvis attributes the albuminuria observed by Bernard after the injection of ordinary serum into the vein.

Pathologically we find albuminuria occurring from venous congestion, in cases of thrombosis of the vena cava, in mitral disease, and in emphysema whenever the right ventricle begins to yield and allow regurgitation into the veins. There is, however, another cause of venous congestion which at first sight would appear likely to have an effect exactly opposite to that which it actually produces. This is obstruction to the flow of blood through the renal artery. When this artery is ligatured, or when the circulation through the kidney is stopped by the action of drugs upon it, we find albumin appearing in the urine after the secretion has been re-established. One would expect to find the kidney pale, and anæmic after ligature of the artery, but, on performing this experiment, Brown-Séquard found that the kidney was deeply congested, the reason of this being that the veins had lost their contractile power, and the blood had consequently flowed backwards into them from the larger venous trunks. We may indeed, form a good conception of the condition by noticing the difference between the paleness of the hands when they are first exposed to cold and the congested blueness which follows a longer

[1] Stockvis, *Sur l'Albuminurie* and *Quelques Mots à propos de la Brochure de M. le Professeur Correnti relative à l'Albuminurie. Journ. publié p. l. Soc. Roy. d. Sciences méd. et nat. de Bruxelles,* Reprint.

exposure. Venous congestion then is the cause of albuminuria depending on alterations in the circulation. In embolism of the kidney the result as respects a part of the organ will be the same as what we find in the whole organ after ligature of the renal artery, and the albuminuria depending upon embolism may be explained in the same way.

The second cause of true albuminuria is alteration in the structure of the kidney, and these alterations may affect the vessels and tubules or the connective tissue stroma in the which they are embedded. In the waxy kidney the vessels are affected and the structure of their walls is changed. It seems not improbable that the altered structure of the vessels may permit the serum-albumin to transude through them in somewhat the same way as the vessels in their normal condition permit the transudation of egg-albumin. In desquamative nephritis we may suppose that the albumin finds its way into the uriniferous tubules, because the epithelial lining which might have prevented its passage has been more or less removed. Even in cases where the albuminuria depends upon organic disease of the kidney, the quantity of albumin present in the urine varies with the condition of the circulation. As a rule it is less during the night and greater during the day. We find too, generally, that a relation subsists between the quantity of urine and the proportion of albumen present in it. When the urine is copious the proportion of albumin is less; when the urine is scanty albumin is usually increased. Now it has been shown by Ludwig and Max Hermann that the quantity of urine increases with the pressure of blood in the renal glomeruli, so that, other things being equal, contraction of the arterioles just at their exit from the Malpighian capsules will increase the pressure in the glomeruli, and augment the secretion of urine. At the same time their partial contraction will probably diminish the pressure in the capillaries, will probably lessen the quantity of the lymph exuding from them into the connective tissue, and will thus lessen the leakage of albumin into the uriniferous tubules. Probably this is the reason why the albumin is usually diminished when the urine is increased, but at any rate the fact is that increased secretion does indicate increased pressure in the glomeruli, and increased secretion is usually, though not always, associated with diminution in the albumin.

I will now relate the case which I wish to bring before you,

and will afterwards return to the bearing of what I have already said upon its pathology.

R. A., aged 33, analytical chemist. Short, slight, fair-haired, sallow complexion, thin. With the exception of being liable to headaches after exertion, he was apparently healthy until ten years ago. He then noticed a tendency to become very easily tired after any exertion. About a year after this (1868) he wished to insure his life, but was rejected on account of the medical officer of the insurance company having discovered albumin in his urine. He then consulted two medical men, who gave him strychnine in doses of about $\frac{1}{30}$th of a grain. This immediately stopped the albumin, but brought on violent headaches and sickness. The albumin at this early stage was only present during the summer months. It came on with work and disappeared with rest. In the winter it was absent, except during one or two severe frosts.

In the following summer it returned in large quantities, and he was advised by his medical man to go to the seaside (Margate and Ramsgate) for the three hot months, to take hot sea-baths, and to abstain from all exertion.

Though the albumen ceased, the patient's strength diminished very much. On his return to London the weather was cooler and he rapidly improved, so as to be able to return to work. In 1870 the albumen returned more persistently, so he was again recommended by a medical man to take a sea-voyage. He went to the Cape of Good Hope; leaving in June and arriving in November, very little, if at all, the better for the trip. This might be due to his ignorance of the care required in selecting the proper food. He stayed six weeks at the Cape, then came back. On his return he tried pancreatic emulsion, and for two or three days it was very successful and stopped the albumen, but after that time it brought it on worse than ever. He then tried the skim-milk treatment for three months. It was very successful at first, but he lost weight rapidly, and the albumin gradually reappeared during the last two weeks of the treatment. On discontinuing it the albumin returned.

In 1872 he was again recommended to take another and longer voyage, and take care of his diet on the way and after his arrival. He had now found that fatty food always brought on albumin, and that meat taken in the morning had a similar effect, but he could take meat with impunity for supper. He now went

to Australia and New Zealand for nearly three years, leaving in October 1872, and returning in June 1875. During the greater part of this time phosphates were very abundant, and although albumin was generally completely absent, it came on whenever he exerted himself much. His strength also did not increase much. On one occasion he took a prescription containing quinine and phosphoric acid, which almost immediately caused albumin to appear in considerable quantities, and it was some time before it again disappeared. After his return in June 1875, he still remained *in statu quo*.

I saw him for the first time in January 1876. No œdema; the heart and lungs were healthy; liver normal; appetite poor; subject to acidity and headache. On inquiry I found that the albuminuria was brought on by exertion either mental or bodily in the morning, by fats such as butter, or by meat for breakfast. After midday he could do work, and could take fat and meat without bringing on the albumin. The quantity of albumin was always greatest when the urine was scanty, and least when the urine was abundant. When he engaged in his work during the forenoon albumin did not come on immediately after breakfast, but began to appear about eleven and remained until about two. When he did not work the albumin did not come on at all. He suffered much from acidity, especially in the morning. The remarkable fact that meat and fats caused albumin to appear, and that by rigid adherence to a farinaceous diet he could completely get rid of the albumin, led me to think that his albuminuria might be connected with imperfect digestion, and I accordingly gave him nitro-muriatic acid before meals. This lessened the acidity, and diminished, but did not completely remove, the albumin, so that I supposed the kidneys to be also in fault.

The quantity of albumin, as I have already mentioned, was always greatest when the urine was scanty, and least when the urine was abundant. This seemed to indicate to me that the albumin came either from the venous radicals in the kidney, or else from the lymphatic spaces in the connective tissue. I therefore attempted to act upon the arterioles of the glomeruli, and increase the secretion of urine by means of digitalis. The experiments made by Mr. Power and myself had shown us that this drug has a special action upon the vessels of the kidney, and, by giving it in small doses, I expected to contract the

arterioles of the glomeruli, and thus while increasing the urine to diminish the pressure in the capillaries and veins, and lessen or remove the albumen. I intended, in fact, to produce by the drug the condition in which the patient had already found there was less albumen.

Two drachms of the infusion three times a day diminished the albumin, but lowered the action of the heart and interfered with digestion. After reducing the dose and finding that still the digitalis disagreed, I stopped it after it had been taken for a fortnight.

There was no history of syphilis, but thinking that the alterative action of mercury might be beneficial, I tried small doses of Hydrarg. c. Creta, but without any beneficial result. I next tried quinine and sulphuric acid, but this brought the albumin in large quantities into the urine, doubled it in fact, within twenty-four hours, just as it had done before.

As he had found benefit from pancreatic emulsion for a day or two on a former occasion, I advised him to try it again, and to stop it after two days so as to prevent the increase of albumin which its continued use had previously induced. The first dose, however, made him worse, and it was accordingly stopped. My attempts to act upon the vessels of the kidney having been futile, and my random treatment with mercury and quinine having also been useless, I determined to try to act upon the secreting structures of the kidney, and accordingly gave arsenic, which has a considerable action upon tissue change, and also appears to possess a special affinity for epithelial structures.

The patient accordingly took 3 ♏ of Fowler's solution at meal-times. Almost at once the albumin disappeared, and the patient was able to do much more work than usual without bringing it back. After giving this for a while I thought that as phosphorus is nearly allied to arsenic the hypophosphites might have a similar action, and accordingly gave him 5 grs. of hypophosphite of soda three times a day. This disagreed with his stomach and increased the albumin. He then returned to Fowler's solution again, and the albumin disappeared. On stopping the medicine the albumin came back, but the liquor sodæ arseniatis stopped it.

On again thinking over the pathology of the case it seemed to me probable that the albumin was derived in great measure, from the intestinal canal, and was due to imperfect digestion of

albuminous substances which were absorbed from the intestine, and excreted in the urine in much the same way as white of egg would have been if the person had swallowed several raw eggs at once. As the pancreatic juice first converts coagulated albumen into a soluble form before finally digesting it, it seemed probable that imperfect pancreatic digestion was the cause of the albuminuria. The failure of the pancreatic emulsion to do good might have been due to the fat causing acidity of the stomach. The chyme being too acid would prevent the pancreatic juice from acting, and would thus make matters worse. I therefore gave pancreatine without the fat, so as to increase the pancreatic digestion without increasing the acidity of the stomach, and this has stopped the albumen also. He has, however, only been taking this for a short time, so that I do not know what the result will ultimately be.

I am inclined to regard the case I have described as due at least in part to imperfect digestion. I am uncertain whether the kidneys have anything to do with it or not. There is no history of nephritis, and the close connection between the digestion which is weak in the forenoon and stronger in the afternoon, the acidity of stomach, and albumin in the forenoon, and the want of these in the evening, seem to point to digestion as the chief cause of the albuminuria. I have not seen any casts, but I have not examined the urine frequently for them. The albuminous body which appears in the urine is probably not serum-albumin, because it only coagulates between 175° and 180° F., while the albumin in a case of chronic Bright's disease which I tested for the purpose of comparison coagulated at 140° F. The point of coagulation varies somewhat according to the amount of urea and uric acid present in the urine, but this variation will hardly account for the difference of more than 30° F. between the coagulating points of the albumen in these two urines.

The points which I wish especially to bring forward are:— 1. The intermittence of the albumin and its connection with the digestion; 2. The absorption of albuminous matters from the intestine as a cause of albuminuria—a cause recognized indeed in several text-books, but often ignored in practice; 3. The utility of arsenic as shown in this case; 4. The possible use of pancreatine; 5. The effect of quinine in increasing the albumin.

ON THE PATHOLOGY OF DROPSY.

(‘ *The Practitioner,*’ VOL. XXXI., *Sept.* 1883.)

DROPSY is an accumulation of fluid in the lymph spaces. These lymph spaces may either be *small,* as in the subcutaneous cellular tissue, and in the substance of organs; or they may be *large,* as in so-called serous cavities, the peritoneum, pericardium, pleura, &c.

In the normal condition, these lymph spaces are only moistened with lymph, whereas in dropsy they may contain it in great quantities.

The question before us, viz. the pathology of dropsy, is simply: How has the lymph come to accumulate in these lymph spaces? Supposing that we have a cistern furnished below with two exit pipes which together are much larger than the supply, it will never become full, although the supply pipe should be running night and day (*vide* Fig. 40). The water rushing into it may wet its sides, but will do nothing more. If we close the exit pipes completely, however, the cistern will soon fill, and, if we close them only partially, the rapidity with which it fills will depend upon the extent to which we close the exit pipes and open the supply pipe, or in other words, it will depend upon the relation between the quantity running in and the quantity running out in a given time. This is exactly what we find in the case of the lymph spaces: these are the cisterns, the arteries and capillaries are the supply pipes, the veins and lymphatic vessels are the exit pipes. In health the lymph spaces are merely moistened with lymph, because, although, constant or nearly constant exudation of lymph is taking place into them from the capillaries, it is at once carried away by the venous radicles and by the lymphatic vessels. In the illustration just given, I have spoken of the cistern as having two exit pipes,

which together are much larger than the supply pipe, but I might have spoken of them as being of unequal size, and of one of them alone being much larger than the supply pipe, although the other may not be so. For not only can the venous radicles and lymphatics together carry away all the lymph which is poured out into the lymph spaces; the venous radicles alone are sufficient for this purpose, so that even when the flow of lymph is entirely stopped by ligature of the lymphatics, no accumulation of fluid in lymph spaces may occur.[1] The lymphatics also may to a great extent

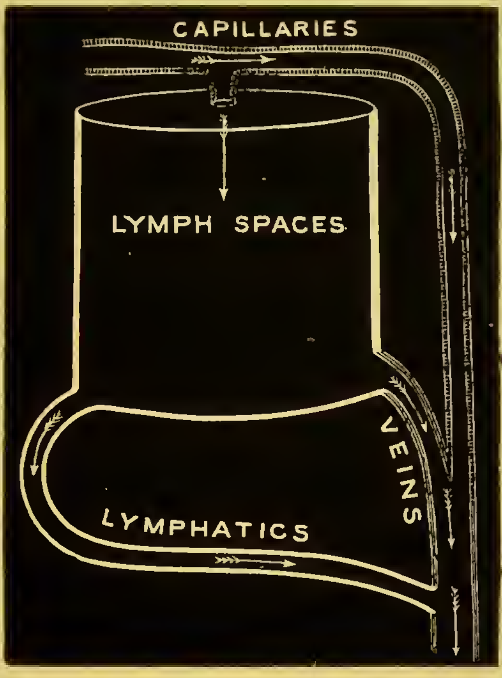

Fig. 40.—Diagram of the relations of the lymph spaces, and vessels.

remove the fluid from the lymph spaces when the veins are obstructed. Thus, as Ranvier and Cohnheim have observed in the dog, and as I have found in the cat, ligature of the inferior vena cava may sometimes produce no œdema whatever in the limbs. This is supposed by Cohnheim to be due chiefly to the establishment of collateral venous circulation.

But on this point I do not feel disposed entirely to agree with him, inasmuch as the veins of the surface in my observations were not dilated to the extent that one would have imagined, and I am inclined rather to believe that the prevention of œdema was due in a great measure to increased action of the lymphatics.

[1] Cohnheim's *Pathology*, second edition, vol. i. p. 485.

Ligature of the veins at once increases the lymphatic stream, as seen in experiments upon animals. When a cannula is inserted into a lymphatic vessel in a dog, the lymph flows in small quantities in slowly succeeding drops with long intervals between. But when the chief vein of the district from which the lymph is supplied is ligatured the lymph flows much more quickly. This may be due partly to the quantity poured out from the capillaries being increased in consequence of the ligature of the vein, but I think we can hardly imagine that it is not in a great measure due also simply to the lymph, which would have been poured out in any case, passing away by the lymphatics when it could no longer be taken up by the veins. It is probable that the proportion of lymph which is removed from the lymph spaces by the veins and lymphatics varies in different individuals.

Ludwig noticed that strong, short-haired dogs yield much lymph. Now if we pat a long- and a short-haired dog we are at once struck with the difference in the feeling of the muscles. In short-haired dogs the muscles are usually hard and well defined, feeling like solid lumps under the skin. In long-haired dogs on the contrary they are soft. We notice similar differences in men, some men have very hard muscles, others very soft. This difference does not appear to affect the muscular power, because it has been found that some of the strongest men are those with soft muscles; and Kühne has shown that the contractile substance of muscle may be regarded as semifluid. The difference between the two sets of muscles lies, not in the muscular substance, but in the fascia by which it is surrounded. In some it appears to be much more developed than in others, and where it is thick it gives to the muscle a feeling of hardness. Now this fascia is a pumping arrangement (*vide* Fig. 41) by which the lymph is drawn out of the muscle and is passed onwards into the lymphatics. It consists of two layers, between which are lymph spaces ending in lymphatic vessels. Each time that the muscle contracts, the inner layer is pressed against the outer and forces the fluid onwards into the lymphatic vessel. Each time that the muscle relaxes, the inner layer tends to fall away from the outer, and thus the lymph from the muscle readily finds its way into it. In the very act of muscular contraction, then, the products of waste are washed out of it by the fresh lymph which flows through it.

This difference in the development of the muscular fascia appears to me, although upon this point I should like to speak

with great reservation, to coincide with differences in the tendencies to *muscular* as distinguished from *articular* rheumatism. Where the muscles are soft from thinness of the fascia, it has appeared to me that the tendency to muscular rheumatism is greater, whereas persons with hard muscles and firm fasciæ have appeared to

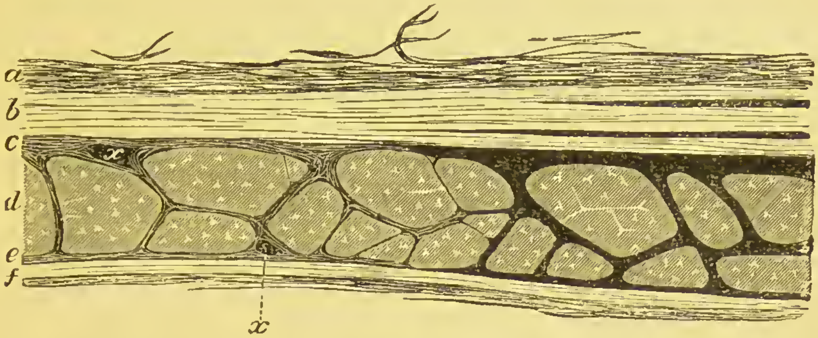

Fig. 41.—Injected lymph spaces from the *fascia lata* of the dog, after Ludwig and Schweigger-Seidel, *Lymphgefässe der Fascien und Sehnen.* The injected spaces are black in the figure.

me to have a greater tendency to articular rheumatism. This is what one might expect, because, if by over-exertion irritant products of waste should be formed in the muscle, they will tend rather to remain there when the fascia is soft, and give rise to muscular pain; while in those whose fascia is hard, they will be removed from the muscle, but may possibly give rise to inflammation in the joints. This point is, I think, worthy of further attention; and careful observations on it might give us valuable data in regard to the true origin of rheumatism.

In the case of the large serous cavities also, we have other pumping arrangements. In the central tendon of the diaphragm (*vide* Fig. 42) we have two layers which are alternately pressed

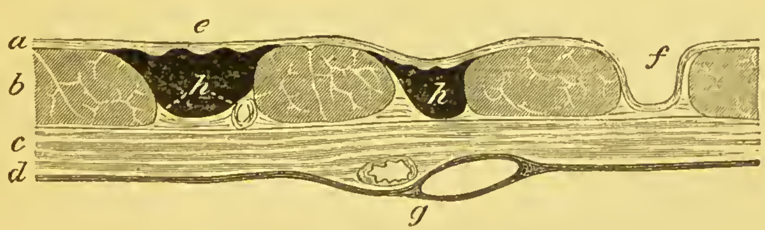

Fig. 42.—Section of central tendon of the diaphragm. The injected lymph spaces, *h* and *h*, are black. At *f* the walls of the space are collapsed. After Ludwig and Schweigger-Seidel, *Lymphgefässe der Fascien und Sehnen.*

together and separated by the movements of respiration, so that they pump the lymph from the peritoneal cavity in much the same

appears to me to point strongly to reabsorption of water from the lymph by the venous radicles, while the solids tend to find their way onwards through the lymphatics.

The flow of blood in the veins, like that of the lymph, depends upon difference of pressure in the peripheral and central ends of the vessels. In the upper part of the body this is aided by gravity, but in the lower parts it is counteracted by gravity. The weight of the longer column of blood in the veins of the body and leg would, to a great extent, prevent the circulation in the veins of the feet were it not aided by muscular action, which presses it onward in much the same way as it does the lymph; and how powerfully muscular action does so has been known for centuries to every barber, who provided his patient with a pole to grasp before letting blood from the arm.

It is aided also to a certain extent by the respiratory action of the thorax and the diastolic relaxation (?) of the heart. In saying "diastolic relaxation" of the heart, I have followed Cohnheim in the recent edition of his *Lectures on General Pathology*, but I am not quite certain that it would not be more correct to say the "systole" of the heart, because, as Brücke has pointed out,[1] the pericardium may be looked upon as a sort of bell-jar, the walls of which, though elastic, are kept more or less rigidly in position by the apposition of their outer surface to the lungs. Each time that the ventricle contracts and drives the blood into the aorta, it tends to cause a vacuum in the pericardial space, and thus tends to draw the blood from the venæ cavæ into the auricle.

The conditions which interfere with the flow of blood in the veins are then: (*a*) want of muscular action, (*b*) want of movement in the thorax, and (*c*) feeble action of the heart, no matter whether we look upon the systole or diastole as being the active power in sucking the blood onwards from the veins.

More important still as causes of complete arrest in a vein are (*d*) pressure upon it from without or (*e*) plugging within.

We have now considered what we termed at first the two exit pipes of the cistern, the veins and the lymphatics. Not only the two together, but either the one or the other separately, appears in the normal condition to be able to remove the lymph which is poured out into the tissues from the blood-vessels, and thus to prevent any accumulation from taking place.

[1] I quote from a lecture I heard him deliver to his class in Vienna in the winter session, 1867-68.

Dropsy then does not occur except we have increased outflow of lymph into the tissues in addition to an interference with its removal by the veins or lymphatics.

We have now to consider the conditions which affect the supply pipe in the illustration with which we commenced, or, in other words, the conditions which increase and diminish the exudation of lymph from the capillaries into the lymph spaces. The first of these is increased supply of blood from dilatation of the arteries supplying a part.

I have already mentioned that, in Ranvier's experiment of tying the vena cava in a dog, the mere stoppage of the venous circulation does not always produce œdema of the legs, the lymph which is exuded from the capillaries being removed either by collateral

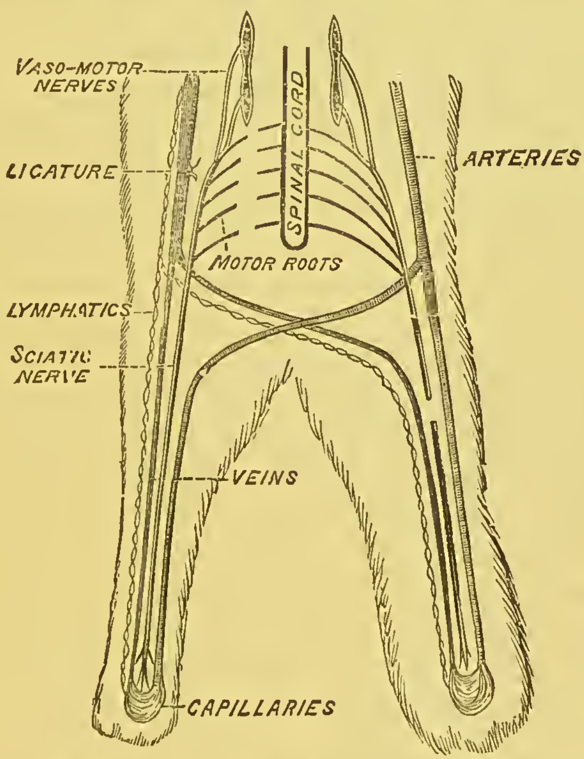

Fig. 44.—Diagram of Ranvier's experiment.

venous circulation or by the lymphatics. The case, however, is usually different when, in addition to the ligature of the vena cava, the sciatic nerve is divided on one side. In consequence of the division the vessels dilate, more blood pours into the limb, more lymph is exuded into the tissues, and the limb with a divided nerve swells up enormously, while the other remains of its normal size, although the venous circulation is equally arrested in

both. That this accumulation of lymph in the tissues of the leg is due to paralysis of the vaso-motor and not of the motor nerves of the limb is proved by dividing on the one side the motor roots of the sciatic and on the other the vaso-motor roots. When the sciatic trunk is divided, there is of course both a vaso-motor and motor paralysis in the limb, because the vaso-motor and motor nerves have been alike divided, and we get the œdema therefore coinciding with the paralysis in the limb; but when we get the motor roots of the sciatic divided and the vaso-motor intact we no longer have the paralysis and the œdema coinciding. The limb on that side where the motor roots have been divided is paralysed, but, the vaso-motor roots being intact, it retains its normal size. On the other side, where the vaso-motor roots are divided while the motor roots are intact, the power of motion is retained, but the limb becomes œdematous. The supply of lymph to the tissues is evidently so much increased by division of the vaso-motor nerves and consequent dilatation of the arteries, that the partially obstructed efferent vessels, veins and lymphatics, can no longer carry the lymph away, and œdema occurs. Sometimes a very slight obstruction is sufficient to produce œdema when there is vaso-motor weakness. This one may sometimes observe in one's own hands. Usually we may walk about for a whole day without feeling the least tendency to swelling in the hands, but every now and again, in a hot sultry day, when there appears to be thunder in the air and we feel limp and languid, we may notice that, after walking about for a while with the hands hanging by the side, the fingers swell to a certain extent, and there may be not only difficulty in drawing on one's gloves, but the fingers may be so distinctly swollen as to be slightly stiff in trying to bend them. Here we have not complete vaso-motor paralysis, but only paresis from the effect of the atmospheric conditions on the vaso-motor nerves, yet the consequence is that the exudation of lymph being increased the slight interference with venous and lymphatic return, caused by the position of the limbs, and aided perhaps by a slight pressure of the clothing, is sufficient to produce œdema.

This, at least, would be the explanation if we were to consider increased exudation of lymph from the blood-vessels as due only to dilatation of the arteries and interference with venous or lymphatic flow. As we shall see shortly, however, there is probably another factor, viz. changes in the capillaries themselves.

As a contrast to the ready production of œdema in the arm

by simple dependent position, aided perhaps by a slight constriction of the clothes and by atmospheric influences, we may take the difficulty with which it occurs under certain experimental conditions.

Frequently, as Ranvier has shown, ligature of the vena cava with accompanying section of the vaso-motor nerves of a limb will cause great œdema; but this is not always the case. For Cohnheim has observed in dogs, and I have myself found a number of years ago in the cat, that simultaneous ligature of the vena cava and section of the sciatic does not always produce œdema. I was very much struck by this in one experiment which I made, for in it, although the vena cava was tied and the sciatic divided in one leg, I could notice almost no increase in the size of either limb. At the same time, as I have already mentioned, the veins on the surface of the limb where the sciatic had been divided were not much swollen, so that I am inclined to believe that a great part of the lymph effused from the capillaries was removed by the lymphatics.

The readiness with which œdema sometimes occurs with very slight alterations in the circulation, and at other times does not occur although the alterations in the circulation are very great, shows us that there are other factors of very great importance. These factors are the condition of the blood and the state of nutrition of the capillary vessels. It is possible that those two conditions really resolve themselves to a great extent, if not entirely, into one, and the main factor is the condition of the capillary vessels. This must necessarily depend to a considerable extent on the condition of the blood. It would, however, be going too far to exclude the condition of the blood from direct influence on the transudation of lymph, and allow it only an indirect action through its effect on the walls of the capillary vessels.

There can, I think, be little doubt that the quality of the blood itself alters the quantity and quality of the lymph exuded, just as differences in the quality of the fluid that you pour upon a filter will affect the quantity and character of the filtrate. But in filtering we find that with many fluids the filter will allow filtration to go on for a length of time, while with others it is speedily choked and allows neither fluid nor solid to pass. In the process of filtration the filter becomes altered, and thus the quantity and quality of the filtrate depend not only on the condition of the filter as originally used, but on the quantity and quality of the

fluid to be filtered, and also on the changes which the filter undergoes during the process of filtration.

One of the most ordinary forms of dropsy is the slight œdema which we notice in the legs of persons suffering from anæmia. There may be no cardiac disease, the lungs may be quite healthy, there may not be the slightest interference with the flow of blood, either through the lymphatics or veins, and yet we find dropsy occurring in the legs; the lymph passing out in such quantities from the blood-vessels that the veins and lymphatics are unable to remove it. It occurs in the legs and not in the other parts of the body, because in the upright position the circulation in the veins and lymphatics is opposed by gravity. In the production of the œdema here we have probably several factors: there is first the watery condition of the blood; next the condition of nutrition of the capillaries; and in addition we probably have a tendency to vaso-motor paresis, for the anæmia lessens the nutrition of the tissues generally, and the vaso-motor centre suffers with the rest.

The occurrence of œdema in the hands when hanging by the sides on a sultry day shows us how very slight an interference with the venous circulation may be sufficient to produce œdema under certain conditions. Usually, however, some interference with the venous or lymphatic flow may be noticed, but there is one case in which œdema may be produced without any apparent interference with either the veins or lymphatics. This occurs in the case of the tongue, for Ostroumoff has found that when the lingual nerve is irritated, not only do the vessels of the tongue dilate, but the whole side of the tongue swells up and becomes œdematous. This might be looked upon as proof positive that mere dilatation of the vessels may cause œdema, but such a conclusion would be premature. We must bear in mind that when we irritate a vaso-dilating nerve we not only make the vessels dilate, but we very probably alter their structure for the time being and render exudation from them more easy.

Claude Bernard's beautiful experiments on the submaxillary gland have taught us that, when the chorda tympani is irritated, the arteries going to the submaxillary gland dilate so much that the blood rushes through them, and through the capillaries that connect them with the veins, in a rapid stream, so rapid that if the vein be punctured the blood issuing from it is no longer dark, but bright and arterial, and instead of trickling out of the vein in slow drops, it jets from it as if from an artery. When this experi-

ment is performed on a normal animal, at the same time that the artery dilates the secreting cells of the gland begin to form saliva, which pours in a stream from the duct during the continuous irritation of the nerve. The secreting cells do not take the material from which they form the saliva directly from the blood, they receive it indirectly from the lymph spaces which surround the alveoli. Into these spaces the lymph exudes from the blood, and from it as from a reservoir the cells take up the materials they want; indeed these spaces will so far act as a reservoir that we may cause the cells to secrete saliva even after the head has been separated from the body, if we take care to fill the lymph spaces with lymph previously by tying the veins of the gland and rendering it to some extent œdematous before cutting off the head. During irritation of the chorda tympani, then, the secreting

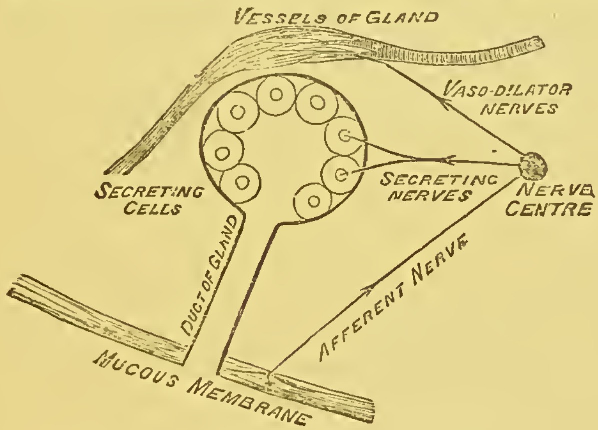

Fig. 45.—Diagram of a salivary gland.

cells of the submaxillary gland take up lymph very rapidly from the lymph spaces which are adjacent to them, and pour it out in the form of saliva. Quickly as they take up the lymph, however, it is still more quickly poured out from the blood-vessels, so that during the continuance of the irritation we not only have a stream of saliva pouring out from the salivary duct, but we have a considerable increase in the amount of lymph which pours out from the cervical lymphatics. This observation, as well as most of the knowledge that we possess in regard to the flow of lymph and the fundamental facts of secretion in general, we owe to Ludwig. In this experiment we have the lymph which exudes from the vessels carried away by two, perhaps three, channels, viz., the secreting cells of the gland, the lymphatics, and probably also, to some extent, the veins. When we obstruct one of these channels by injecting into

the salivary gland a solution of quinine, or dilute hydrochloric acid, more lymph is poured out from the arteries than the lymphatics and veins together can carry away, and the gland becomes œdematous.

A very remarkable change occurs in the results of this experiment when we administer a dose of atropine to the animal. If we irritate the chorda tympani after poisoning by atropine, the vessels dilate as before, the veins become full, and the current of blood in them becomes rapid, but not a drop of saliva is secreted by the cells.

We are usually in the habit of assuming that the chorda tympani contains two sets of fibres, one of which goes to the secreting cells and another to the vessels; the one set stimulates the glands to functional activity, and the other causes the vessels to dilate.

We usually explain the effect of atropine by saying that it paralyses the peripheral ends of the secreting nerves in the cells of the gland; but if this were the only explanation, we ought to have a result very much like what we get by injecting a solution of quinine into the gland. We ought to have the gland either becoming œdematous, or the flow of lymph in the lymphatics passing from the gland should be enormously accelerated; the lymph which exudes from the vessels ought either to be carried away rapidly by the efferent vessels, or should accumulate and produce œdema, but neither of these results occurs. Heidenhain has found that the gland does not become œdematous under these circumstances, and the flow of lymph through the cervical lymphatics is not accelerated. Now I have already mentioned that under normal conditions, even when the gland is forming large quantities of saliva, and thus removing a quantity of the fluid poured out from the vessels, we have an increased flow of lymph occurring during irritation of the chorda tympani nerve. I can see then no other way of explaining the fact that after poisoning by atropine it does not produce either secretion of saliva or increased flow of lymph from the lymphatics, than by assuming that the atropine has so altered the vessels as to prevent the exudation of lymph from them into the lymph spaces at the same time that it has allowed the arteries to dilate; for we know that the secreting cells of the gland are still able to form saliva because irritation of the sympathetic nerve will cause secretion even after the power of the chorda tympani to cause secretion has been completely paralysed.

I should not be prepared at present to deny that the chorda

tympani has fibres which stimulate the secreting cells to increased action.

But what I wish to insist upon here is that in all probability atropine has an action upon the vessels of the gland which has hitherto been entirely overlooked. Yet such an action as I have mentioned is one of the greatest practical importance, because if we are able through the action of our drugs to prevent the exudation of lymph from the blood-vessels into the lymph spaces, it will enormously increase our power to prevent or to lessen dropsy.

In a remarkable research upon the action of drugs on the heart and vessels, Dr. Gaskell showed that dilute acids cause relaxation of the muscular substance both of the heart and blood-vessels, while dilute alkalies have an opposite effect, and cause contraction. He showed also that certain drugs resemble acids in their action, while others resemble alkalies. Thus muscarine, the poisonous principle of mushrooms, tends like acids to cause relaxation of the ventricle and dilatation of the blood-vessels, while atropine has an opposite effect, and resembles alkalies in its action.

Dr. Cash and I have repeated Dr. Gaskell's experiments on the effect of acids and alkalies on the vessels. This action is tested by killing a frog and then keeping up the circulation in it artificially, by connecting the aorta with a vessel containing diluted blood or saline solution. As the pressure is constant, the rapidity with which the fluid flows out of the veins affords a measure of the dilatation or contraction of the vessels. We have observed that not only do the vessels dilate under the influence of acids added to the circulating fluid, so that the liquid pours much more readily out of the veins than before, but that the walls of the vessels themselves appear to become much more permeable, so that the tissues tend to become œdematous.

Under the influence of alkalies the vessels contract, the flow of fluid out of the veins becomes scanty, and no œdema is observed in the tissues. This experiment affords, I think, a clue to the changes in the vascular walls which give rise to dropsy, although much research will still be necessary before our knowledge on this subject is either complete or accurate.

In regard to the action of acids and alkalies upon the vessels, however, we may obtain useful information from the effect

of experiments on the submaxillary gland. I have already mentioned that atropine, which Gaskell found to act upon the vessels like alkalies, appears to arrest the flow of lymph from the blood-vessels into the lymph spaces, so that the secretion of saliva is entirely arrested, while the flow of lymph through the lymphatics is certainly not increased, nor yet does the gland become œdematous, although the blood-vessels are fully dilated. As I have said, moreover, by injecting a solution of quinine or dilute hydrochloric acid into the duct of the gland, the secretion of saliva is stopped, but here the gland becomes œdematous. These facts seem then to indicate that the acid has increased the tendency to exudation of lymph from the blood-vessels.

I may again shortly recapitulate what we have now gone over, as to the general sources of dropsy, and then proceed to say a few words regarding particular kinds of dropsy.

Shortly, then, dropsy depends on the quantity of lymph effused from the blood-vessels being greater than the veins and lymphatics can carry away. This may depend either upon obstruction to the veins and lymphatics, or excessive exudation from the blood-vessels. The veins and lymphatics in the normal condition are able, however, to carry away so much more fluid than is effused from the capillaries, that, unless the obstruction to them is very great indeed, no œdema occurs so long as the capillaries are in their normal condition.

In almost all cases of dropsy, then, we may consider that the capillaries are so altered as to allow a greater amount of transudation. The exact nature of the alteration we do not at present know; but such experiments as we have on the subject tend to show that acids, or substances having an action upon the vessels similar to that of acids, may have very much to do with this effect.

The forms of dropsy may be divided either according to their supposed causation or to their seat.

From their causation they may be divided into dropsy of passive congestion, hydræmic dropsy, and inflammatory dropsy.

These may again be subdivided into cardiac dropsy, hepatic dropsy, anæmic dropsy, renal dropsy, scarlatinal dropsy, according to the tissue on the affection of which the dropsy appears to depend.

Another class of dropsies are nervous dropsies, and it is perhaps

at the present moment rather doubtful how these dropsies are produced, and how far they are dependent on changes in the circulation of blood in the part affected, and how far on alterations in the permeability of the vascular walls.

In dividing dropsies according to their seat we have general œdema, ascites, hydropericardium, pleuritic effusion, hydrocele, and effusion into joints.

In regard to the particular dropsies I shall say only a few words, as, in questions of this sort, if we can settle the general causation of any condition, the application of it to particular instances is easy.

I have mentioned that sometimes, even in health, the mere weight of the column of blood in the arms, and perhaps slight constriction by the clothes on a sultry day, may produce slight œdema in the hands. A similar condition is noticed in the legs in œdema, and it is not unfrequently very marked in cases of fatty heart. Indeed, the occurrence of œdema in the legs when the urine is normal, and no cardiac murmur is to be heard, is, I think, a very important point in the diagnosis of fatty heart.

We find it also markedly in the legs where the venous flow is obstructed in consequence of emphysema or mitral disease. In such cases the effect of the greater pressure of blood in the venous radicals in producing œdema is well shown by its disappearance when the patient has been lying down. That even in such cases, however, the permeability of the capillaries has much to do with the production of œdema is shown by the fact that every now and again we meet with persons who are suffering from great emphysema and excessive interference of the venous circulation, and yet little or no œdema is to be noticed. A sudden change in the condition of the patient, and one too attended by a relief of the general symptoms, may cause œdema to appear.

I was much struck with a case of this sort which I saw a year or two ago. An old woman was suffering from chronic bronchitis with emphysema, the lungs were choked with mucus which she could not expectorate, her face was becoming rapidly more and more livid, she was apparently at the point of death, and yet there was but very slight œdema in the legs. I gave her an emetic of ipecacuanha with the effect of greatly relieving her, clearing the lungs, and removing the lividity, but the day afterwards the œdema in the feet was very well marked. This shows that even in those cases the permeability of the capillaries has much to do

with the production of dropsy, although such cases are generally ascribed almost entirely to venous obstruction, and this obstruction has no doubt a great deal to do with their causation.

Another form of œdema is that which occurs in connection with albuminuria—or perhaps it might be better to say, with Cohnheim, in the earlier stages of albuminuria. For Cohnheim divides the dropsies which occur in albuminuria into two classes: the first, which occurs in the earlier stages, is due to changes in the permeability of the vessels, allowing a more rapid exudation of fluid from them. The dropsy which occurs in the later stages, and which affects the serous cavities as well as subcutaneous cellular tissue, he regards as due to passive congestion, secondary to changes in the heart.

The first form, then, of albuminuric dropsy, which affects only the subcutaneous cellular tissue, differs from the dropsy of passive congestion not only by being confined to the subcutaneous tissue, but in affecting different parts of it. In the dropsy of passive congestion the parts which swell are those which are most dependent, such as the feet and legs; but in the dropsy of albuminuria the parts affected are those where the cellular tissue is loose, such as the face. The dropsy of albuminuria is usually ascribed to a more watery condition of the blood, but Cohnheim shows that this alone is not sufficient to produce œdema. So long as the capillaries are in a healthy condition, they do not allow more exudation to take place when the blood is rendered watery by the intravenous injection of a large quantity of dilute saline solution than they do when the blood is in its normal condition. But when the capillaries have become altered by inflammation, which renders them more permeable than usual, the effect of any alteration in the concentration of the blood is at once manifest. The dilute blood, although it does not pass through healthy capillaries more easily than the concentrated blood, exudes through the altered capillaries very much more rapidly than the normal blood, as is shown by the much greater quantity of lymph which is poured out from the vessels of the inflamed limb of a dog, when its blood is diluted by the injection of a large quantity of saline solution into the veins. This experiment shows us that, although alterations in the composition of the blood will not produce œdema when the vessels are healthy, yet, when the vessels are already altered by disease, a diluted condition of the blood tends greatly to increase the œdema; and we thus obtain to some extent an explanation of the good effects of diuretics and

purgatives in dropsy; for these remedies, by removing water from the body, will lessen the dilution of the blood.

The ready occurrence of œdema in scarlet fever, and as a consequence of a sudden chill, is ascribed by Cohnheim to increased permeability of the vessels due to inflammatory changes in them. No doubt he is to a great extent right, and the œdema occurs chiefly in consequence of changes in the vessels, but we must try and find out more particularly what the changes are if we are to learn much regarding the rational treatment of œdema. The term *inflammatory* does not help us—at least, does not help us much. We must try and find out whether we can bring the changes in the vessels into direct connection with the action of drugs.

Now one of the most striking forms of dropsy is probably the intense œdema which is said to occur to the natives of the West Coast of Africa, or in Europeans resident in some hot climates in consequence of sudden wetting. This comes on suddenly in the absence of cardiac disease, and in the absence of albuminuria. Now in hot climates the skin secretes much sweat, and this sudden œdema is just what we would expect if stoppage of the functional activity of the sweat glands were to occur without a corresponding arrest of exudation from the vessels. In poisoning by belladonna or atropine, as we have seen, the secretion of saliva is arrested, but the exudation from the vessels of the salivary gland is also diminished. We have no similar experiments regarding the action of atropine upon the vessels of the skin, but probably a similar action occurs in regard to the lymphatics of the skin, for we know that atropine arrests the secretion of sweat in almost exactly the same way as it arrests the secretion of saliva.

In consequence of the diminished exudation from the vessels, we find no œdema occurring in the salivary gland after poisoning by atropine, although the vessels are much dilated, nor do we find any œdema occurring in the skin under similar conditions, even although the cutaneous vessels may be so much dilated that the patient poisoned by atropine presents an erythematous flush all over, like one suffering from scarlet fever. In scarlet fever, also, the secretion from the skin appears to be diminished or arrested, for the skin is dry and has a pungent feeling, which is probably due to the want of cooling by evaporation. But at this time there is no œdema. The skin is red, the vessels are fully dilated, the secretion from the sweat glands is probably completely arrested, and yet there is no œdema. But we can readily see that, if the

vessels should by any means become readily permeable before the sweat glands had resumed their function, we should at once have all the conditions for acute œdema.

We can readily see, also, that the blood-vessels will be more readily acted upon by any substance which is circulating in the blood than the sweat glands would be, for, in order to act upon the sweat glands, any substance must first pass through the vessels into the lymph spaces adjacent to the sweat glands, and then be taken up by the secreting cells.

If therefore any substance should either be absorbed from the intestinal canal, or be formed in the tissues of a patient suffering from scarlet fever, which will cause permeability of the capillaries without stimulating secretion of the sweat glands, we would expect œdema to occur. Now it would almost appear that certain abnormalities, either in digestion or in tissue change, precede the œdema of scarlet fever and the albuminuria which accompanies it, for here, I think, we must look upon the albuminuria and the œdema, not as dependent upon one another, but as consequences of one common cause, which probably is the presence of something in the blood which acts as a poison upon the tissues already predisposed to its action. Now Dr. Mahomed found what he regards as a pre-albuminuric stage of scarlet fever, in which he noticed a peculiar reaction of the urine, which gave a blue with guaiac. If the patient was left alone when this action was noticed, albuminuria came on, but if a brisk purgative was at once administered, the abnormal condition passed away and no injury resulted.

The œdema of scarlet fever is usually considered to be due to some chill, but we do find cases in which the utmost care has been taken, and where we cannot trace any distinct history of a chill, and yet œdema occurs. A chill may, no doubt, not only induce changes in the circulation, but may induce changes in the alimentary canal, and in the tissues generally, by which substances may be formed which, after their absorption into the blood, may increase the permeability of the vessels. But I think, at the same time, we must keep our eyes open to the possibility of such substances being formed even without any exposure.

The phenomena which occur in urticaria are, I think, instructive in regard to the possible causation of dropsy by poisons circulating in the blood, for there we frequently find that after the ingestion of certain articles of diet the skin becomes bright red, the capillaries dilated, and what are really spots of local œdema occur. These

may be very limited, or they may be extensive, as in the case of a lady of my acquaintance in whom a single strawberry will produce such intense urticaria that the face swells up and the eyes become almost closed by the accompanying œdema.

Now in urticaria the round white swellings resembling the effects of the sting of a nettle suggest the idea that they arise from some point in the centre, and it seems not improbable that the originating point is a sweat gland. Both in urticaria and in the sudden œdema occurring after a chill in hot climates, I am inclined to regard the sweat glands as playing an important part, and paralysis of the secreting power as a cause of œdema, not only because the fluid effused from the blood-vessels ceases to be drained away from them, but also because it seems to me not improbable that, although the secretion is not fully elaborated, such changes may occur as will produce acid in the secreting cells. Normally this will be carried away in the sweat, but if retained it may react upon the capillaries in the same way as Cash and I have found in our experiments, and thus increase the amount of fluid poured out from them.

I have preferred in this paper on the pathology of dropsy, to deal most at length with the particular points which seem to me most likely to lead us to a rational and successful treatment.

Again to recapitulate. Dropsy consists in the accumulation of lymph in small lymph spaces or large serous cavities. The accumulation is caused by more lymph being poured out from the vessels than can be removed by the lymphatics and veins. Obstruction to the lymphatics and veins will rarely produce dropsy unless the quantity exuded from the capillaries is greater than the normal. The exudation from the capillaries is increased by changes which occur in them. These changes are classed generally by Cohnheim under the name of *inflammatory*. This designation is too vague to give us any guide to treatment, and I have tried to point out that the increased permeability of the vessels is probably due to an alteration in them. It may be produced by acids circulating in the blood, as in the experiments of Cash and myself; by acids applied to them from without, as in Ludwig's experiment with the submaxillary gland; or by acids, or poisons which act like acids, absorbed from the intestinal canal, or formed in the tissues themselves (cf. p. 274).

APPENDIX.

Since I wrote this paper I have become acquainted with some facts which seem to me to support the views regarding the action of acids which I have advanced. Through the kindness of Professor Hans Meyer of Dorpat, I have received an Inaugural Dissertation, written under his direction by Jacob Feitelberg, on the action of various poisons upon the acidity of the blood. In this paper the author shows that a number of poisons have the power of increasing the acidity of the blood. They appear to do this by diminishing oxidation, as it is found that, along with an increase of acid, which chiefly appears to be sarcolactic acid in the blood, the carbolic acid in it is lessened. One drug which has this power in a marked degree is arsenic, as we know one of the common symptoms of arsenic poisoning is an œdematous condition of the eyelids. This effect of arsenic on the amount of acid in the blood seems to me to afford a ready explanation of the œdema which it produces.

ON THE ACTION AND USE OF DIURETICS.

('*Practitioner*,' VOL. XXXII., *April and May*, 1884.)

THE part which water plays in the animal body is a very important one. Not merely does it form by far the greatest part of the body itself, constituting no less than 59 per cent. of its weight, but the life of all the tissues is essentially dependent on its presence in them. Without water no vital function can go on. In the dry climate of Egypt wheat has been preserved unchanged since the days of the Pharaohs, without the slightest tendency to growth having occurred until it was moistened; and when rotifer animalculæ are dried up they will fly about as dust devoid of any appearance of life, until they are again put into the water. In the complicated organism of the human body the same thing occurs, though to a much less extent. We cannot have any one of the tissues completely desiccated, otherwise it would, like the rotifer, lose all its vital functions, but, unlike it, would not regain them when a fresh supply of water was brought to it. Diminution of water to a certain extent may be endured by the tissues without injury, but it will diminish tissue change in them, while increase of water will augment it. When much water is drunk, as certain experiments have shown, the tissue change is increased to such an extent that the body must rapidly waste, and the necessity for more food to supply them is indicated by the ravenous appetite which is induced, as well as by the loss of body weight which occurs when the appetite is not gratified. Not only does water increase tissue change, it removes the waste products produced more rapidly than usual, and, indeed, the effect of water-drinking upon the body, in increasing tissue change and removing the waste products, may be compared to raking out the ashes from a fire, and at the same time making it burn more brightly. All the water drunk must find its way out of the body

again by one channel or another. Some of it passes off through the lungs, and a little by the bowels, but the greater proportion passes through the skin and kidneys. The action of these organs is compensatory.

It is difficult to estimate precisely how much is excreted by the skin, but probably it may be taken at about two-thirds of the quantity eliminated by the kidneys. When the skin is active the kidneys have, consequently, less work to do, and when the secretion from the skin is sluggish, the kidneys must secrete all the more. Some years ago, while making experiments upon the urinary secretion, I found that on the sudden occurrence of a cold day after a succession of warm ones, the amount of urine secreted was very nearly doubled. One reason of this compensatory function of the skin and kidneys probably is that the secretion in both, like the secretion in other glands, depends to a great extent on the supply of blood going to them. When the supply of blood is greater, the secretion is also increased. On a warm day, or when the body is exposed to external warmth, the vessels of the skin dilate, and the cutaneous glands are freely supplied with blood. The application of cold to the surface of the body, on the contrary, causes the cutaneous vessels to contract, and thus more blood is driven to the internal organs—the kidney amongst the rest.

The utility of this arrangement is obvious, for although the skin has an excreting function complementary to that of the kidneys, its chief function is that of regulating the temperature of the body. When the temperature rises either in consequence of active muscular exercise or from any other cause, the vessels of the skin dilate, and if the temperature of the external air be lower than that of the body, heat is lost by radiation. The blood returns cooled from the cutaneous capillaries to the internal organs, and thus the temperature is again brought down to the normal. But even when the temperature of the external air, instead of being lower, is higher than that of the body, the skin still acts as a cooling apparatus by means of the evaporation of sweat. The quantity of heat which is changed into potential energy in the process of converting liquid water into gaseous steam is very great. Five and a half times as much heat are required to convert boiling water into steam as to raise the same amount of water from the freezing to the boiling point. The immense loss of heat occasioned by the evaporation of the perspiration is so great that in negroes

on the west coast of Africa it has been noticed that the skin, while perspiring profusely, is as cold as marble, and Sir Charles Blagdon observed that in a room with a temperature of 128° F. his side felt quite cold to the touch. The skin cooled by perspiration therefore acts even with a high external temperature as a refrigerating apparatus to the blood, and prevents the temperature of the body from rising too high. When the external temperature is low the vessels of the skin contract so that little blood circulates through them, and loss of heat by conduction or radiation or by perspiration is, to a great extent, prevented. It is evident that on a hot, dry day, with active exertion the loss of water by the skin must be considerable, and sometimes work must be done with but a limited supply of water to drink. At the same time the products of waste must be removed, and under such circumstances, although the skin excretes a very large quantity of water, it excretes but a small quantity of solids. The kidneys are thus put to a great disadvantage. They have still to excrete the solids: they can only do so when these solids are in a state of solution, and yet if they excrete the usual amount of water while more than usual is being thrown off from the skin, and, perhaps, less than usual is being drunk, the proper proportion of water in the body will rapidly be reduced below the normal, and its functions seriously disturbed. In order to prevent this there seems to be an arrangement in the kidney whereby water is retained after it has served its purpose of washing the solids so far through the kidneys that they can be afterwards eliminated without it. The products of tissue waste must be removed in a state of solution from the part of the kidney where they are excreted, and yet sometimes provision must be made for the water by which they are washed out being retained in the body. The urine in mammals and amphibia is liquid; in birds and reptiles it is semi-fluid or solid, yet the solid constituents are removed in solution from the urinary tubules, and the water in which they are dissolved is afterwards absorbed.

In cold weather, on the other hand, the vessels of the skin are contracted, there is little or no perspiration, and yet it may so happen that the individual is obliged to live on food containing a large proportion of water. This difficulty must also be met, and so in the kidney we have a provision for the removal of water without solids.

We may say then that the kidney has a threefold function:—1st, that of excretion of waste products; 2ndly, a provision for the

removal of excessive water; and 3rdly, an arrangement for the retention of water in the body by its re-absorption, after it has washed out the waste products. On looking at the kidney we find three structures which seem to be connected with these three functions, viz.: (1) convoluted tubules with epithelial cells, which in all probability are the chief structures for excreting waste products; (2) the malpighian corpuscles for excreting water along with some solids; and (3) usually one or more constrictions in the tubule which may serve the purpose of preventing too rapid exit of the water, and thus allow time for its re-absorption in cases where its retention is desirable, as for example on a hot day and when the supply of drinking-water is very limited.

The process of secretion in the kidney was regarded by Bowman as consisting of the filtration of water from the vessels of the glomeruli into the tubule, and the excretion of waste products by the epithelium lining the tubule. Ludwig, however, came to look upon it rather as a process of filtration and re-absorption; a dilute solution of urea and salts being, according to him, poured out from the malpighian corpuscles and gradually concentrated by the absorption of water in its passage along the tubules. This theory had so many facts in its favour that it was for a good while exclusively adopted, but latterly Heidenhain in an admirable series of experiments has shown that substances like indigo are certainly excreted by the epithelium of the tubules. At the same time Hüfner has shown by a comparison of the structure of the kidney in fishes, frogs, tortoises, birds, and mammals, that the form of the tubules closely agrees with that required for the re-absorption of water in each case. Fishes have a low blood-pressure, and so the resistance in the kidney requires to be small in order to allow of the secretion of urine. Living as they do in water, they do not require any apparatus for its retention in the body. In them therefore the tubule is short and wide, and destitute of any constriction which would retard the outflow of fluid. In frogs there must be ample provision for the retention of water in the body, as evaporation takes place freely from their skin. In them we find, as we might expect, that the tubule, and especially the contracted part of it, is very long. In tortoises no evaporation from the skin can take place, and in them the contracted part of the tubule is short. This renders it probable that, while the ideas advanced by Bowman and supported by Heidenhain are in the main true, the re-absorption of water on which Ludwig lays so much stress is also

a most important factor in the secretion of urine under different circumstances.

But it is not only rendered probable by the facts of comparative anatomy; it appears to be proved by direct experiment. Ribbert[1] has extirpated the medullary substance of the kidney in the rabbit while leaving the cortical substance. He has thus succeeded in collecting the urine as it is excreted by the malpighian corpuscles before it has passed through Henle's loops, and has found that the urine secreted by the cortical substance alone is much more watery than that which is secreted by the entire kidney, a

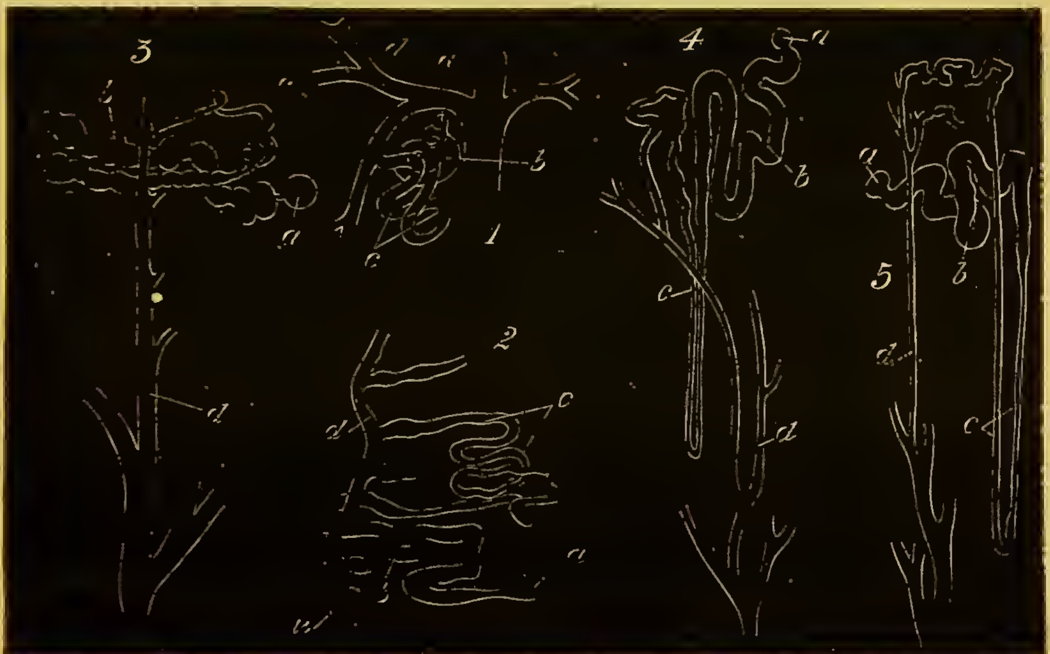

Fig. 46.—Diagram showing the form of the urinary tubules in different classes of animals, after Hüfner. 1. Fish. 2. Frog. 3. Tortoise. 4. Bird. 5. Mammal. The letters have the same significance in each. *a.* Capsule of the glomerulus. *b.* Convoluted tubule. *c.* Loop. *d.* Collecting tube. *u* in 2 indicates the transverse section of the ureter.

fact which appears conclusively to prove that water is actually re-absorbed, and the urine rendered more concentrated, during its passage through the tubules in the medullary substance.

In the frog and triton the arrangement of the kidney is such as to allow of a much more complete investigation of the different factors in secretion than in mammals, because in amphibia the glomeruli which separate the water and the tubules which excrete

[1] Ribbert, *Virchow's Archiv*, July 1883, p. 189.

the solids receive their blood supply to a great extent independently. The glomeruli are supplied by branches of the renal artery. The tubules are supplied by a vein which proceeds from the posterior extremities, and entering the kidney, breaks up into a capillary plexus bearing a somewhat similar relation to the renal tubules, to that which the portal vein bears to the lobules of the liver. It is therefore called the portal vein of the kidney.

The arterial circulation in the glomeruli is not entirely distinct from the venous portal circulation round the tubules, for the efferent arteries of the glomeruli unite with the portal capillaries, and, moreover, arterial twigs also pass directly from the renal artery into the capillary venous plexus. Still the two systems are so far distinct that Nussbaum has been able to ascertain with considerable exactitude the part played by each in

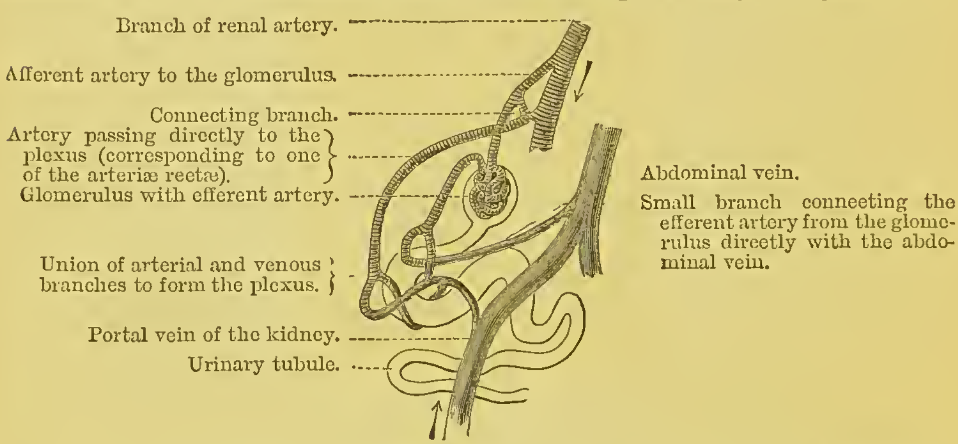

Fig. 47.—Diagram of the circulation in the kidney of the newt. Modified from Nussbaum.

secretion. By ligaturing the renal artery he destroys the functional activity of the glomeruli, and by ligaturing the portal vein of the kidney he destroys that of the tubules. By injecting a substance into the circulation after ligature either of the artery or the vein, and observing whether it is excreted or not, he determines whether it is excreted by the glomeruli or the tubules. In this way he finds that sugar, peptones, and albumen pass out through the glomeruli exclusively, for they are not excreted when the renal arteries are tied. Albumen, however, only passes out through the glomeruli when an abnormal change has already occurred in the vascular wall; as, for example, after the circulation has been arrested for a while by ligature of the renal artery. Indigo-carmine, when injected after ligature of the renal arteries,

passes into the epithelium of the tubules, but it does not give rise to any secretion of water, so that the bladder is found empty. Urea, on the contrary, is not only excreted by the tubules after ligature of the renal artery, but carries with it, in the process of secretion, a considerable quantity of water from the venous plexus, so that the bladder becomes partially filled.

The excretion of water, therefore, takes place in a double manner: it passes out through the glomeruli when the renal arteries are free, and it passes out from the venous plexus along with urea, even although the renal arteries are tied.

In the kidneys of the higher animals and of man the glomeruli and the tubules do not receive blood from two entirely different sources, but there is an arrangement somewhat similar to that just

Fig. 48.—Diagrammatic sketch of the blood-vessels in a mammalian kidney. From Schweigger-Seidel, *Die Nieren*, Halle, 1865. *o* is an artery ascending into the cortical substance of the kidney. *p* is a branch from it which divides into two branches, *q* and *P*. *q* breaks up at once into a number of twigs. *P* is the afferent artery to a glomerulus (*s*) of the lowest row. *t* is the afferent vessel of the glomerulus; it divides into two branches, one of which (*u*) ascends towards the cortex, whilst the other (*v*) descends towards the medulla.

described; for the plexus surrounding the tubules does not receive blood only from the efferent vessels of the malpighian corpuscles, it gets blood also directly from the renal arteries.

There are three channels by which the blood may pass from the renal arteries into the venous plexus without going through the glomeruli.

The first is the inosculation which takes place between the terminal twigs of the renal artery and the venous plexus on the surface of the kidney directly under the capsule (stellate veins, Fig. 35, p. 301).

The second channel is formed by small branches given off

directly by the interlobular arteries or by the afferent arteries before they reach the glomeruli.[1] The former of these may be regarded as corresponding to the artery which passes directly to the plexus in the newt, and the latter to the branch connecting it with the afferent artery (Fig. 48). These arterial twigs are found not only near the surface of the kidney, but also in the deeper layers of the cortical substance.[2]

The third and most important channel is afforded by the arteriæ rectæ, which spring from the branches of the renal artery at the boundary between the cortical and medullary substance and pass into the medulla, where they form a plexus with elongated meshes surrounding Henle's loops and the collecting tubules. Near their origin the arteriæ rectæ inosculate with the venous plexus surrounding the convoluted tubules (Fig. 49, p. 359).

Through these three channels it is possible for blood to reach the secreting structures of the kidney and there get rid of urea, salts, &c., without losing water by its passage through the glomeruli. On the other hand, if these vessels contract, while the size of the renal artery and the pressure of the blood within it remain unaltered, more blood will be forced into the malpighian corpuscles, and thus the quantity of water excreted will be increased. At the same time the contraction of the arteriæ rectæ will probably diminish absorption from the tubules, and thus the quantity of water excreted will be increased in a twofold manner.

Circumstances modifying the Secretion of Urine.—The experiments of Ludwig and his pupils have shown that the amount of urine secreted depends very closely upon the pressure of blood in the malpighian corpuscles, or, to put it more exactly, on the difference of pressure between the blood in these corpuscles and the pressure within the tubules. For if the ureter be tied so that the pressure of urine in the tubules is increased, the secretion is greatly diminished, and even arrested, although the pressure of blood in the renal artery be high.

A somewhat similar effect to that of ligature of the ureter is produced by ligature of the renal vein, for the blood accumulating in the venous plexus surrounding the tubules compresses them so as to prevent the flow of urine through them. A similar condition may occur from cardiac or pulmonary disease obstructing the venous circulation.

[1] Ludwig, *Handwörterbuch d. Physiol.*, v. R. Wagner, Bd. 2.

[2] Schweigger-Seidel, *Die Nieren*, p. 67; Heidenhain, *Hermann's Handbuch d. Physiologie*, vol. v. Th. I. p. 293.

But unless in exceptional circumstances which alter the pressure within the tubules, such as compression of the tubules by congestion of the venous plexus, as in cardiac disease, impaction of a calculus in the ureter, or pressure on the ureters by dropsical

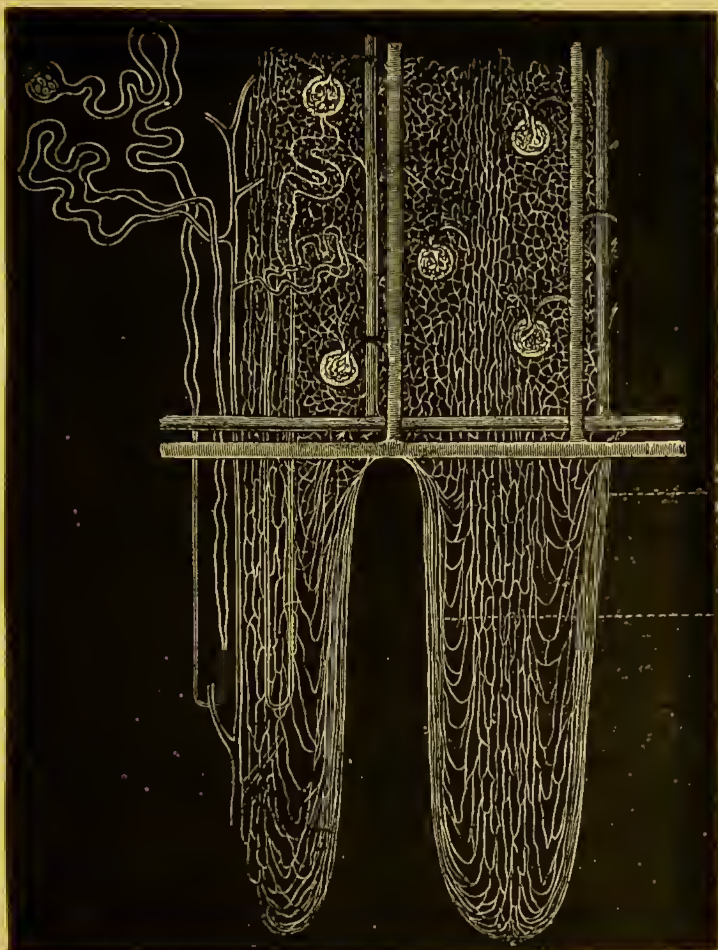

Fig. 49.—Diagram of the tubules and vascular supply of the kidney. On the left is a tubule alone, in the middle is a tubule along with the blood-vessels, on the right are blood-vessels only.

accumulations or tumours, the rapidity of the secretion of urine depends on two factors:—(1) arterial pressure in the glomeruli; and (2) the composition of the blood.

The pressure of blood in the glomeruli may be raised—

(1) by increase of the arterial tension generally,

(2) by increased tension locally.

Thus the effect of cold winds and cold baths is probably due chiefly to their power of contracting the vessels in other parts of the body, and thus driving more blood into the renal artery, and

increasing the pressure in the glomeruli. In some pathological conditions also we find the blood pressure high, and the secretion of urine abundant. This occurs, as a general rule, in persons suffering from cirrhotic or contracting kidney, in whom the pulse is generally tense, and the blood pressure high, although in these cases also the high blood pressure is probably not the only factor in the increased secretion.

Such a general increase may be brought about by greater action of the heart, or by contraction of the blood-vessels in other vascular areas, such as the intestines, muscles, or skin, by nervous stimulation, exposure to cold, or the action of drugs.

The pressure may be increased locally by dilatation of the renal arteries, *e.g.* from section of the vaso-motor nerves, or possibly stimulation of vaso-dilating nerves.

In addition to such increase of pressure in the glomeruli by increase of blood supply to them, we must not, however, forget the possibility of increased pressure in them by contraction of the efferent vessels leading from them, as well as of those arterial twigs (arteriæ rectæ) which pass directly to the venous plexus surrounding the tubules, and which form no inconsiderable part of the vascular supply of the kidney.

Alterations in the size of the renal vessels were formerly ascertained simply by exposing the kidney and observing its colour, contraction of the arteries being associated with paleness, and dilatation with redness of the organ. A much more exact method has been introduced by Roy, who incloses the kidney in a capsule filled with oil and connected with a registering apparatus. When the vessels dilate, the kidney increases in size, and diminishes when it contracts, so that the alterations can be readily recorded on the same revolving cylinder on which the general blood pressure is registered by the manometer.

The pressure of blood in the glomeruli may be diminished generally—

(1) by failure of the heart's action, or

(2) by dilatation of vessels in larger areas, as the intestines, muscles, and skin.

The pressure of blood in the glomeruli may be diminished locally by contraction of the renal arteries, or of the afferent branches to the glomeruli.

The heart's action may fail from many causes, which have already been discussed more particularly.

Dilatation of the vessels in the skin, intestines, &c., may be caused by exposure to warmth, by the action of drugs, or by paralysis due to nervous injury.

Section of the splanchnics or of the spinal cord causes paralysis of the renal arteries, and ought, therefore, to increase the secretion of urine. This does occur, though not invariably, when the splanchnics are divided; but section of the spinal cord, by paralysing the intestinal and other vessels, lowers the blood pressure so much that the supply of blood to the kidney is not only much below the normal, but is so small that the secretion of urine is generally almost completely arrested.

The nerves of the kidney consist of a number of small branches running along the renal artery and containing a number of ganglia. When these nerves are cut the vessels of the kidney dilate; when they are stimulated the vessels contract. A number of these fibres pass to the kidney from the spinal cord through the splanchnics, so that when the splanchnics are cut the vessels of the kidney usually dilate, and when they are irritated, they contract.

The whole of the nerves, however, do not pass through the splanchnics, for stimulation of a sensory nerve, of the medulla oblongata, or of the spinal cord in the neck, will cause contraction of the renal vessels after both splanchnics have been cut, and section of the splanchnics does not always cause the renal vessels to dilate.

The nervous centre for the renal arteries is probably, like the chief vaso-motor centre for the body generally, in the medulla oblongata; but in all probability there are also subsidiary centres in the spinal cord and in the solar and mesenteric plexuses.

The reason for supposing these latter centres to exist is, that stimulation of the peripheral end of the splanchnic, divided at its passage through the diaphragm, causes contraction of both kidneys, and the vessels of the kidney of the side opposite to the stimulated nerve commence to contract later than that on the same side. A delay like this in the action of the stimulus means that it has not acted directly, but through the medium of ganglia.

When the splanchnics are divided, the vessels of the kidney sometimes dilate and the kidney increases in size; a profuse secretion of urine may take place, which quickly increases to a maximum and remains for a considerable time. This, however,

is not a constant effect, and not unfrequently the vessels do not dilate, and the kidney, instead of increasing, diminishes in size. This is what to a certain extent might be expected, inasmuch as a section of the splanchnics causes dilatation of the intestinal vessels and lowers the blood pressure, and thus diminishes the supply of blood to the kidney.

When a puncture is made in the medulla oblongata in the floor of the fourth ventricle, profuse secretion also occurs, but this differs from that caused by section of the splanchnics, in being preceded by slight diminution, in rising rapidly to a maximum, and then rapidly falling. These characters seem to show that it is due to irritation of some vaso-dilating mechanism [1] rather than to any paralysis.

Stimulation of the vaso-motor centre in the medulla oblongata by venous blood, or by drugs such as strychnine or digitalis, has a twofold action on the kidney, for it tends to cause contraction not only in the vessels of the kidney, but in those of other parts of the body. The effect on the kidney is thus a complicated one, for the contraction of the intestinal and other vessels by raising the blood pressure tends to drive blood into the kidneys at the same time that the contraction of the renal arteries tends to keep it out. When the renal nerves are cut, the renal vessels no longer oppose the entrance of blood, and therefore the renal vessels dilate very greatly when the vaso-motor centre is stimulated; but when the renal nerves are intact the result is a varying one, for sometimes contraction of the renal vessels may be so great as to prevent the entrance of blood into the kidney, however high the general blood pressure may rise; at other times the general high blood pressure may be able to dilate the renal arteries in spite of any resistance they may offer. These different conditions may occur subsequently to one another; and this stimulation of the vaso-motor centre may cause contraction of the renal vessels succeeded by dilatation, or *vice versâ.* Thus Mr. Power and I found that on injecting digitalis into the circulation of a dog the blood pressure rose, but the secretion of urine was either greatly diminished or ceased altogether. Here it is evident that the renal vessels had contracted so much as to prevent the circulation through the kidney, notwithstanding the rise which had taken place in the blood pressure. After a while the blood pressure began to fall, and then the secretion of urine rose much above its normal,

[1] Heidenhain, *Hermann's Handbuch d. Physiologie*, vol. v. Th. 1, p. 366.

showing that the general blood pressure was then able again to drive the blood into the kidneys.[1]

Similar observations were made by Mr. Pye and myself with regard to erythrophlœum, and the accompanying curves show well the result of the mutual action of rise in blood pressure and contraction of the renal arteries upon the secretion of urine. It will be noticed that at first the blood pressure rises more quickly than the secretion of urine, the circulation through the kidney appearing to be opposed by the renal arteries. This opposition is then

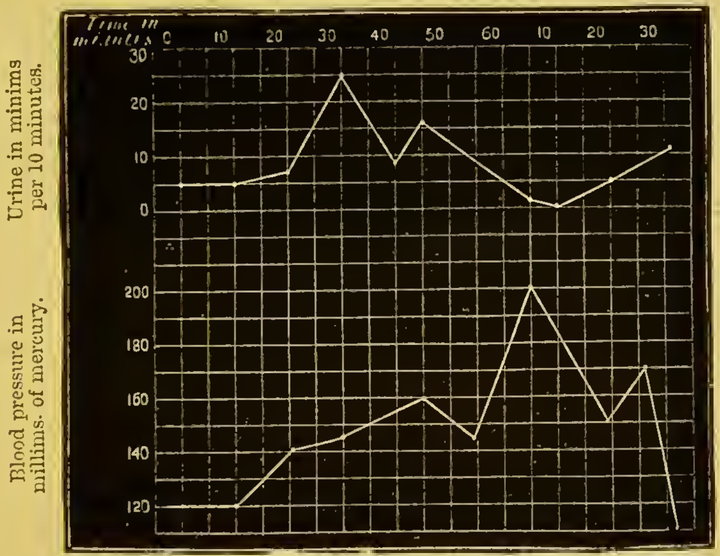

Fig. 50.—Curves showing the effect of erythrophlœum upon the blood pressure and secretion of urine. From *Phil. Trans.*, vol. 167.

overcome, and the secretion of the urine rises more quickly than the general blood pressure. The renal vessels again appear to contract, so that the urine diminishes while the blood pressure rises still further. We have next oscillations due first to one factor and then to the other being predominant; and then, when the blood pressure rises to its maximum, we find that the urine is at its minimum, the secretion of urine again rising as the blood pressure falls.

A good deal of discussion has arisen regarding the mode of action of digitalis, and it has been stated by many to act as a diuretic only in cases of heart disease, and to have no diuretic action in health. In my own experiments, however, I found that it acted as a very marked diuretic even in health, and the explanation of this discrepancy may possibly be that, in my own case, the

[1] *Royal Society's Proceedings*, No. 153, 1874

normal blood pressure was low, whereas in the others it was probably much higher; but I am uncertain regarding the true explanation, though I am certain of the fact.

By causing increased secretion of water through the kidneys diuretics may increase the concentration of the blood and thus produce thirst, or cause absorption of water from the intercellular tissue or serous cavities in dropsies. In my own experiments on digitalis I weighed all my food and measured all my drink for nearly six months, taking exactly the same quantity every day. After producing profuse diuresis by a large dose of digitaline (sixty milligrammes in two days), such thirst ensued that I was forced to take a quantity of water to allay it.[1]

Mode of Action of Diuretics.—From what has already been said, it is evident that diuretics may act in several ways. They may act:

(A) On the circulation in the kidney, raising the pressure in the glomeruli.

(1) *Locally* (*a*) by contracting the efferent vessels, or the arterial twigs which pass directly to the capillary plexus; (*b*) by causing dilatation of the renal arteries, and thus increasing the supply of blood to the kidney. This they may do also in more ways than one, for they may either paralyse the vaso-motor nerves of the kidney, or act on vaso-dilating mechanisms.

(2) They may raise the blood pressure *generally* by causing the contraction of vessels in other parts of the body.

(B) Other diuretics may act on the secreting cells of the tubules, and may increase both the amount of water and the amount of solids excreted by them.

Diuretics have been by some classified as stimulating and sedative; and the sedative class agrees very closely with the one which we have just indicated as acting on the kidneys through the circulation.

From what has been said of the action of diuretics it is evident that we may hope to do much more by combining them, than by using them singly. Thus we see that digitalis, instead of acting as a diuretic, may completely arrest the renal circulation, and stop the secretion altogether. If, however, we can combine it with something which will produce dilatation of the renal vessels, while the general blood pressure remains high, we shall greatly increase the

[1] The experiments were made in 1865 and published in part in my thesis on *Digitalis, with some Observations on Urine.* London: Churchill, 1868.

circulation through the kidney, and obtain the desired result. Experiments in regard to this were made by Grützner with nitrite of sodium. He found that this substance increased the secretion of urine when the blood pressure was reduced to a minimum by curara; and he found that it also had this effect when the blood pressure was raised by imperfect respiration. When the vaso-motor centre was excessively stimulated however, by allowing the blood to become very venous, the nitrite of sodium no longer produced any increase of secretion.

All nitrites have an action on the blood-vessels more or less alike. All of them cause the arterioles to dilate either by an action on their muscular walls or on the peripheral terminations of vaso-motor nerves. One of the commonest diuretics is spiritus ætheris nitrosi, which contains nitrite of ethyl. Sometimes this is combined with acetate of ammonia as a diaphoretic, sometimes with digitalis, broom, or spirit of juniper, as a diuretic. We have already seen that the action of the skin and of the kidneys are complementary, so that if we increase the secretion from the one we tend to diminish that of the other. At first sight then it might appear curious that we should use the same drug to increase the secretion of both. Yet there can be little doubt from clinical experience that nitrous ether is useful for both purposes, and the reason of its utility at once becomes evident when we remember that it is strictly neither diaphoretic nor diuretic, but its action is simply that of dilating the vessels, and consequently allowing the blood to flow freely in whatever direction it may be determined by other conditions. If by combining it with digitalis we can dilate the renal arteries while those of the other parts of the body remain contracted, it is evident that we shall obtain a much freer flow of urine than we could by the administration of digitalis alone.

If instead of a diuretic like digitalis, which acts chiefly through the blood-vessels, we combine spirits of nitrous ether with salts of potassium, which act on the secreting structure, it is evident that we are likely to obtain from the increased circulation in the kidneys caused by the nitrites a much more plentiful secretion than the potassium salts alone would have produced.

The mode of action of diuretics may perhaps be rendered clearer by the following table. At present the data we possess are insufficient to allow us to classify diuretics with absolute certainty according to their mode of action, yet I think the accompanying table may be fairly said to represent our present knowledge of the

subject, its imperfections being indicated by the number of notes of interrogation which the table contains.

TABLE SHOWING THE PROBABLE MODE OF ACTION OF DIURETICS.

DIURETICS	Raise arterial pressure ...	Generally	Increased action of the heart by alcohol. Contraction of vessels in intestine and throughout the body.		Digitalis. Erythrophlœum. Strophanthus. Squill. Convallaria. Strychnia. Cold to surface.
		Locally in kidney...	Contract efferent vessels or arteria recta so as to raise pressure in glomerulus and lessen absorption in tubules, or both.	By action on vaso-motor centres.	? The same as in preceding list.
				By local action on vessels or nervous structures in the kidney itself.	? Broom. ? Turpentine. ? Juniper. ? Copaiba. ? Cantharides.
			Dilate afferent vessels	Paralyse vaso-motor nerves or involuntary muscular fibre. Stimulate vaso-dilating nerves	Nitrites. Alcohol. ? Urea.*
	Act on the secreting nerves, or secreting cells of the kidney itself.	Increase water excreted.			Urea. Caffeine.
		Increase solids excreted.			Liquor potassæ. Potassium acetate, &c.

* When a current of blood is passed artificially through an excised kidney, the stream is much accelerated by the addition of urea. Abeles, *Sitz-Ber. d. k. k. Wiener Akad.* Bd. 87, Abt. 3, April, 1883.

It not infrequently happens that one is able to understand a hypothesis more clearly when it is put in a diagrammatic form, and that one can thus perceive more readily the particular points in which it may be erroneous, even if true in the main. I therefore subjoin a diagram of the circulation and secreting apparatus of the kidney to show the parts which are probably affected by different diuretics :—

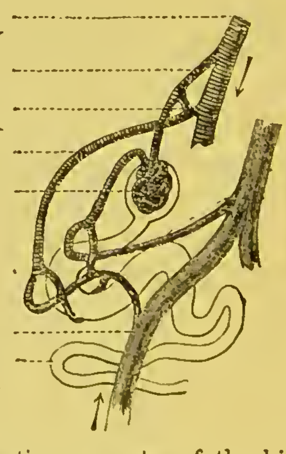

Fig. 51.—Diagram to show the parts of the secreting apparatus of the kidney which are probably affected by different diuretics.

Uses.—Diuretics may be employed either for the purpose of removing water or solids from the body. They are used :

1st, to remove the excess of fluid met with in the tissues and serous cavities in cases of dropsy.

2nd, to hasten the removal of injurious waste products and poisonous substances from the blood.

3rd, to dilute the urine.

In cases where the accumulation of fluid depends on venous congestion, as for example in cardiac dropsy, those diuretics which act on the general vascular system, like digitalis, strophanthus, squill, or erythrophlœum, are most efficient because they tend to remove the cause of the dropsy, as well as to assist the absorption and excretion of the fluid already effused.

When the dropsy depends on the disease of the kidneys or liver, other diuretics should either be given instead of, or along with, digitalis or squill, even in cases of cardiac disease. Where digitalis or squill are not proving efficacious, the addition of a little blue pill greatly assists their action, though it would be hard to say in what way it does so.

In dropsy depending on kidney disease, decoction of broom, and oil of juniper, and nitrous ether, are amongst the most reliable diuretics, and copaiba in hepatic dropsy.

Diuretics are used to increase the secretion of solids in febrile conditions, and in cases of kidney disease where the excretion of waste products is deficient, and their retention threatens to prove injurious. In such cases, nitrate and bi-tartrate of potassium, turpentine, and juniper, and caffeine are useful.

Diuretics are also used to increase the proportion of water in the urine, and thus to prevent the solids being deposited from it and forming calculi in the kidney or bladder; or even to dissolve again concretions which have been already formed.

Water is perhaps the most powerful diuretic we possess, although fewer experiments have been made with it upon animals than with the others. The diuretic action of water drunk by a healthy man is very marked, and it appears impossible to explain its elimination by a mere increase in blood-pressure, whether general or local. It has, as we have remarked, the power of increasing tissue change, and thus multiplying the products of tissue waste which result from it, but it removes those waste products as fast as they are formed, and thus, by giving rise to increased appetite, provides fresh nutriment for the tissues, and thus acts as a true tonic. In persons who are accustomed to take too little water, the products of tissue waste may be formed faster than they are removed, and

thus accumulating may give rise to disease. If water be freely drunk by such persons, the products of waste will be removed, and health maintained or restored. Thus many gouty persons are accustomed to take little or no water except in the form of a small cup of tea or coffee daily, besides what they get in the form of wine or beer. In such people a large tumbler of water drunk every morning, and especially with the addition of some nitrate or carbonate of potassium, will prevent a gouty paroxysm.. Still more numerous, possibly, is the class of people who rise in the morning feeling weak and languid, more tired, indeed, than when they went to bed. Now fatigue may be regarded as the imperfect response of muscles and nerves to stimuli, and such an imperfection in their action may be due either to their imperfect nutrition or to the imperfect removal of the products of their waste. Many such people are well fed, they sleep soundly, and it seems almost impossible to believe that the fatigue which they feel in the morning can result from imperfect nutrition, more especially as one finds that after moving about, the languor appears in a great measure to pass off. It seems to me that this languor must depend upon imperfect removal of the waste products from the body, as we know that the secretion of urine in healthy persons is generally much less during the night than during the day. I am therefore in the habit of advising such people to drink a tumbler of water before going to bed in order to aid the secretion of urine and elimination of the waste products during the night. In some cases, though not in all, the result has been satisfactory, and possibly might have been still more so had I added to the water the bi-carbonate and nitrate of potassium which, as I have already mentioned, is so useful in cases of gout.

Lately a plan of treating gout by draughts of water at intervals during the day has been a good deal employed and is in many cases successful. As an example of this I subjoin the diet used along with this treatment by a medical friend of mine who has been a martyr to gout, but who feels himself perfectly well as long as he adheres strictly to this course of diet:—

7.30 A.M. Ten fluid ounces very hot water.

8 A.M. Breakfast: Equal parts of weak tea and milk, a small quantity of white sugar, a slice of fat bacon without a strip of lean, bread and fresh butter.

1 P.M. Milk pudding, rice, sago, tapioca, macaroni, or blanc mange, and small biscuits with butter, ten fluid ounces hot water.

4 to 5 P.M. Ten fluid ounces hot water.
6 P.M. Dinner: White fish or fowl (usually boiled), greens, bread, no potatoes, claret seven fluid ounces.
8 to 9 P.M. Ten fluid ounces hot water.
11 P.M. Ten fluid ounces hot water.

If he indulges either in meat or game, or drinks copiously of claret, or omits one or two glasses of hot water, he feels gouty and gravelly next day. It is obvious that by this plan of treatment, in which the ingestion of nitrogenous food is most strictly limited, at the same time that every facility is given for the elimination of the products of nitrogenous waste by the large quantities of hot water drunk in the course of the day, the accumulation of waste in the tissues ought to be most effectually prevented.

Adjuvants to Diuretics.—As the amount of urine secreted depends upon the difference in pressure between the blood in the glomeruli and the urine in the tubules, it is evident that any pressure on the tubules, whether caused by obstruction of the ureter by a calculus, by the mechanical pressure of dropsical accumulations in the abdomen, or by distension of the venous plexus in the kidney itself, will tend to lessen the secretion of urine. Consequently we sometimes find that in such cases diuretics fail to act until the pressure has been relieved by paracentesis in cases of dropsy, or the venous congestion lessened by the use of a brisk purgative, or by cupping over the loins.

If the venous congestion be very great, as in cases of mitral disease or of chronic bronchitis with emphysema and dilated heart, bleeding from the arm may be advantageous or even imperatively necessary. In dilated heart and in mitral incompetence the action of digitalis on the heart itself, strengthening its action and enabling it more effectually to pump the blood out of the venous into the arterial system and thus to reduce venous congestion, will aid its action upon the kidneys.

INDEX.

Richard Clay & Sons,
BREAD STREET HILL, LONDON,
Bungay, Suffolk.